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Vol. 25 SEPTEMBER, 1933 No. 9

SURFACE WATER RESOURCES OF NEW JERSEY

By O. W. Hartwell

(*District Engineer, United States Geological Survey, Trenton, N. J.*)

The United States Geological Survey was created over 50 years ago to coördinate the efforts of several agencies that were engaged in exploring the great and unknown West. Major John W. Powell, Director of the Survey from 1881 to 1894, was a broad philosophical naturalist rather than a specialist in the field of geology. During his explorations in the arid regions he became interested in the struggles of the settlers to bring water to their lands for irrigation. He laid the ground work for a systematic study of the problems of these settlers, including the determination of the available water supply, and organized the irrigation survey as a branch of the Geological Survey for this purpose in 1888. The first step was the establishment of an instruction camp for the hydrographic phase of this survey at Embudo, New Mexico, in the fall of that year. Out of this branch grew the Reclamation Act and later the establishment of the Reclamation Service as an independent bureau.

As the East has become more densely settled, water consciousness has traveled from the arid regions eastward across the continent. Our great cities are confronted with problems of water supply scarcely less acute than those that confronted the early settlers along the meager streams of the arid Southwest. These cities must foresee their needs a decade or a generation ahead and provide for those needs by acquiring sources of water for their constantly growing population;

and so the necessity for accurately determining stream flow and for protecting streams from contamination by industrial wastes or through human occupancy is now recognized in the East as well as in the West.

The water-resources branch of the Geological Survey, which grew out of the early irrigation survey, is now divided into five divisions, whose functions may be recognized in their names—ground water, quality of water, power resources, water utilization, and surface waters. The present paper deals with the activities of the surface-water division, which is engaged largely in the establishment and maintenance of stream-gaging stations at specific points on rivers and creeks throughout the United States. The field operations of this division are conducted through 35 permanent district offices. The boundaries of the 35 districts conform to State boundaries, because much of the work is done in coöperation with the States.

In New Jersey stream gaging was first conducted by hydrographers having headquarters in Washington. The present district office was opened in 1921 as the result of an agreement for coöperation between the State Department of Conservation and Development and the United States Geological Survey. Since 1929 the State Water Policy Commission has been the coöperating organization.

The personnel of the district office is as follows:

District engineer, in general charge of field and office work.

Office engineer, in immediate charge of analysis of field reports and records and preparation of stream-flow records for publication.

Two assistant engineers, making current-meter measurements of discharge and having charge of construction and maintenance of equipment at gaging stations. These engineers spend some time in this office making computations under the direction of the office engineer.

One district clerk, engaged in bookkeeping, stenography, filing of records, and correspondence, and in charge of supplies issued to local gage readers.

About 40 local observers check the operation of automatic water-stage recorders and make weekly reports to the district office.

There are at present 51 gaging stations in New Jersey. The total area of the State is 8,224 square miles, so that we have one station for each 161 square miles of area. The number of stations per square mile is about the same in Massachusetts (one to 159 square miles) and in Connecticut (one to 172 square miles). These two States are

fairly comparable with New Jersey in size and in need for stream-flow records.

GAGING OF STREAMS

At each gaging station the elevation of the water surface is used as the index of flow. To observe this index elevation we use a staff gage or an automatic recording gage. All but two of the gaging stations in New Jersey are equipped with automatic recorders. The recorder is installed in a suitable shelter over a float well in the bank of the stream. The well is located far enough back in the bank to insure protection from freezing in the winter and protection from floating debris in time of flood. The well is connected with the stream by a horizontal intake pipe, which is placed low enough to bring the water to the well at the lowest stages.

The automatic recorder makes its record by plotting a graph on cross-section paper. Recorders have a time scale ranging from 1 to $2\frac{1}{2}$ inches a day and a gage-height scale ranging from 1 to 5 feet of gage height for each inch on the graph. Details of shelters for these recorders have been worked out through experience, and plans for these installations have been well standardized. The automatic recorders, although developed by private manufacturers, have been improved largely under the guidance of experience gained in stream gaging. I will not present detailed plans for instrument and shelter at this time, but I will be glad to give such details to anyone who is interested in them.

In order that the gage height may be a true indication of the discharge the gage must be located at a properly selected point along the stream. The gage is usually installed just above a shoal or constriction in the stream, which is known as the control. Wherever possible this control should be a permanent formation. Where nature does not provide a suitable control, one may be constructed. Several gaging stations in New Jersey are equipped with artificial concrete controls. These consist of low dams across the streams about 1 foot in height. The cross section and profile of the controls are so designed as to permit passage of the water with the least distrubance, and to constrict the stream in such a way that there will be a measurable head of water on the control at times of low water. Occasionally an existing dam may be found to be suitable for control, but a dam that would make a suitable control for measuring floods may be so wide as to be incapable of gaging low flows, or there may be so many com-

plicating factors in connection with the flow past the dam that it becomes more economical and more satisfactory to locate the gaging station at some other point.

The record of daily gage height is translated into daily discharge by means of a rating curve. This curve indicates the flow corresponding to each different gage height. The rating curve is determined from current-meter measurements of discharge, which are made from time to time at different river stages. When measuring a small stream the engineer will wade in at a suitable cross section, measuring the depth and mean velocity at equal intervals across the stream. On large streams or during times of high water the principle of measurement and the instrument used are the same, but the meter is placed in the desired positions through being suspended in the water from a bridge or cable.

We use a small current meter, known as the Price, for this work. During recent years several technical articles on the use of the current-meter have attempted to show that the Price meter does not perform well under certain extreme conditions, generally in very turbulent water. We do not have to use a meter under such unfavorable conditions. The Geological Survey is making thousands of accurate discharge measurements each year with the Price meter. We are able to find or develop cross sections near our gaging stations where conditions of flow, are reasonably uniform and capable of accurate measurement with this meter.

Some idea of the accuracy of current-meter work may be obtained by inspection of figure 1, which is based on the rating curve for the gaging station on Assunpink Creek at Trenton, N. J. The measurements at this station were made at several different cross sections, by several different men, using several different meters. The measurements fall very consistently on the curve. They cannot be consistent simply through the repetition of some error, because they were not made at the same cross section or by the same man and meter. They are consistent because they are all accurate.

In the office, tabulations of daily gage heights are prepared from the automatic recorder charts; rating curves are plotted from the measurements made by the engineers; and from these two are prepared tabulations of daily and monthly discharge. After each record has been completed it is compared with records for nearby streams. Comparisons are made by plotting, on the same sheet, daily hydrographs for the streams that are to be compared. Comparisons are

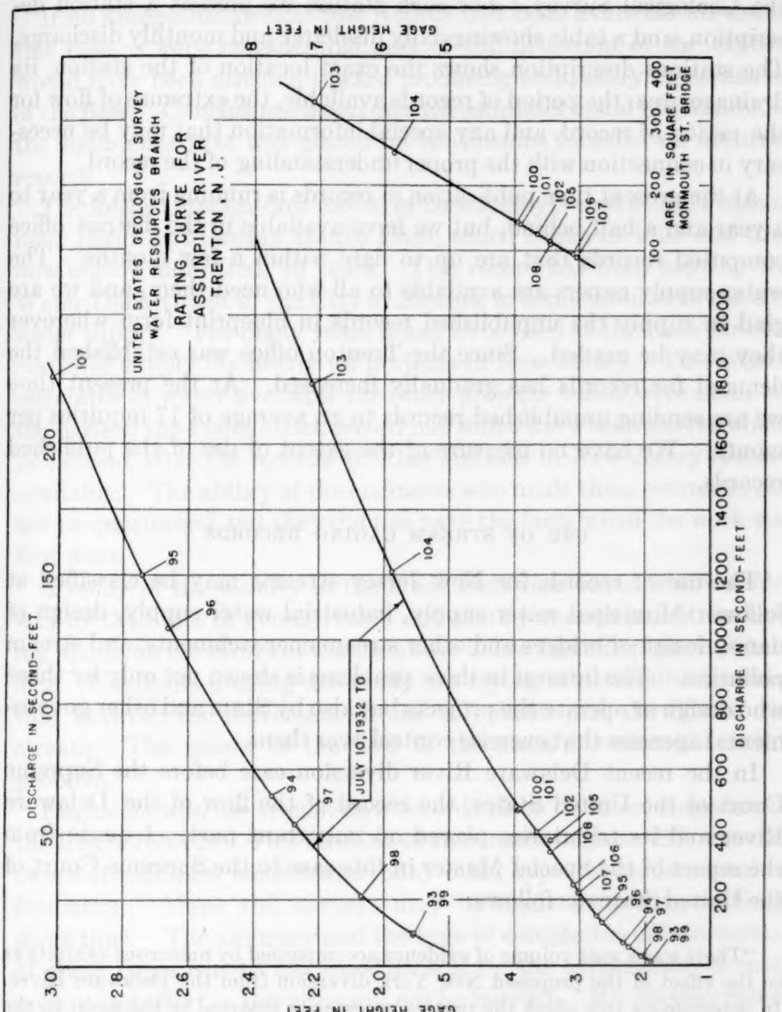

FIG. 1

also made by recording the run-off per square mile on an outline map of the State. When records appear to be discordant, they are again checked, or a search is made for some explanation for the discrepancy.

The records are published annually in the water-supply papers of

the Geological Survey. For each station we present a station description, and a table showing daily discharge and monthly discharge. The stations description shows the exact location of the station, its drainage area, the period of records available, the extremes of flow for the period of record, and any special information that may be necessary in connection with the proper understanding of the record.

At the present time publication of records is running from a year to a year and a half behind, but we have available in the district office computed records that are up to date within a few months. The water-supply papers are available to all who need them, and we are glad to supply the unpublished records in blueprint form wherever they may be needed. Since the Trenton office was established the demand for records has gradually increased. At the present time we are sending unpublished records to an average of 17 inquiries per month. We have no measure of the extent of use of the published records.

USE OF STREAM GAGING RECORDS

The use of records for New Jersey streams may be classified as follows: Municipal water supply, industrial water supply, design of dams, design of bridges and other stream encroachments, and stream pollution. The interest in these problems is shown not only by those who design or operate the projects but also by State and other governmental agencies that exercise control over them.

In the recent Delaware River diversion case before the Supreme Court of the United States, the record of the flow of the Delaware River and its tributaries played an important part. I quote from the report of the Special Master in this case to the Supreme Court of the United States as follows:

"There was a vast volume of evidence accompanied by numerous exhibits as to the effect of the proposed New York diversion from the Delaware River. In determining this effect the parties necessarily resorted in the main to the same basic data. The most reliable information obtainable consisted of the stream-flow records of the gaging stations of the United States Geological Survey and some State records. . . . . In determining what the effect of the New York diversion would be in the future, the parties attempted to show what the probable effect of the New York diversion would have been if it had existed in the past. The stream-flow records of the Delaware River do not exist for any long period of time. It would have been much more satisfactory if complete stream-flow records had been available for a number of points on the Delaware River for a period, say, of 50 years."

If no acceptable stream-flow records had been available for use in this case, a very considerable part of the attention of the experts would have been directed toward producing and justifying estimates of the flow. Conclusions based on such estimates could not command the confidence that was placed on conclusions founded on accurate records.

The longest stream-flow record in New Jersey is that of the Pequannock River at Macopin Intake Dam, which began in 1892 and thus now covers more than 40 years. This record has been kept by the Water Department of the City of Newark in connection with the city water supply. For many years it had to be used as the basis for estimates of supply for nearly all projects in New Jersey. I have seen estimates of water available for other projects which were made on the basis of the Pequannock record but which have been altered about 20 percent after the records at other stations in New Jersey became available. The ability of the engineers who made these estimates can not be questioned, but they did not have the facts when the work was first done.

A study of the salinity in the lower Delaware River is now under way by the State of Pennsylvania and also by various industries having plants on the shores of the Delaware below Philadelphia and Camden. Engineers making this study are trying to determine the relation between the movement of the salt water and the flow of the stream. The record of the flow of the stream is essential in this problem.

Engineers who use stream-flow records place the most emphasis on the longer records. This element of time marks a great difference between stream-flow records and many other types of fundamental information. Maps and surveys may be made in a comparatively short time. The accuracy and the time of completion of information of these types can be advanced at will by the expenditure of more money and effort. But time will not be hurried. If a 50-year record of the flow of a stream is going to be needed tomorrow, that record must have been started 50 years ago. No other investment of effort or money can produce the record.

Our first records of the Delaware River were started about 25 years ago, with no knowledge as to the problems to which they would be applied. The records have been continued through the years with no definite problems in mind, but only with the faith that here was an invaluable resource whose measure would some day be needed.

These records were sufficiently valuable in the Delaware River Diversion case alone to justify all the expenditure of time and money that went into them.

(Presented before the 4-States Section meeting, April 27, 1933.)

WATER SOFTENING AT THOMASVILLE, GA.

By Lowell Cady

(Of Wiedeman and Singleton, Consulting Engineers, Atlanta, Ga.)

That part of Georgia which lies south of an irregular line drawn from Columbus through Macon to Augusta, and known to geologists as the "Fall Line," is called the Coastal Plain section. Its area embraces more than half the entire State. That section of this area which obtains its underground water from the cretaceous sands has, of course, a soft water, but the greater part of the area obtains its water from the eocene rocks. This water has a mineral content varying from 100 to 1100 p.p.m.

Every municipal water works plant in the Coastal Plain section obtains its water from underground sources. Generally, the wells yield abundantly; the water contains practically no turbidity and has a low bacterial content.

The economic losses and personal inconveniences to water users, due to hard water, heretofore has received little or no attention from municipal authorities in charge of water supplies in this section. The City of Thomasville is the first municipality in this section to give its customers the advantages of soft water.

Thomasville, located near the Georgia-Florida line, has a populalation of about 15,000. The city, besides operating the softening plant, owns and operates a modern steam turbine driven electric generating plant and electrical distribution system.

The present water, with about 12 grains hardness, is obtained from three deep wells with a maximum capacity of 1250 gallons per minute. At present, only two wells, with a total capacity of 950 gallons per minute, pump water to the softening plant where it is reduced, at present, to a hardness of 4 grains.

ZEOLITE PROCESS VS LIME SODA PROCESS

In considering the softening of any water supply, the first problem which must be considered is the degree to which the water should be softened. The next question is what method of softening is most economical.

The answer to the first problem must be based largely on experience, because there is no definite dividing line between a hard and a soft water. In many manufacturing processes, a water of zero hardness

TABLE 1

Costs of lime-soda and zeolite methods in dollars

Lime soda method	
Lime	$9.14
Soda ash	4.37
Aluminum sulphate	0.87
Total chemical cost	$14.38
Water (washing and miscellaneous) @ 5 cents per 1000 gallons	3.42
Power	3.34
Labor	4.02
Repairs and supplies	1.00
Total operating cost	26.16
Fixed charges:	
Interest	9.59
Depreciation	4.60
Total fixed charges	14.19
Total cost per million gallons	40.35
Cost per 1000 gallons—4.035 cents.	
Zeolite method	
Salt	24.85
Water (washing, etc.)	3.42
Power	1.00
Labor	4.02
Repairs and supplies	1.00
Total operating cost	34.29
Fixed charges:	
Interest	6.72
Depreciation	3.20
Total fixed charges	9.92
Total cost per million gallons	44.21
Cost per 1000 gallons—4.421 cents.	

may be desirable and the expenditure necessary to produce such a water is justified. For general domestic use, however, a water containing 4 to 5 grains of hardness appears to be quite satisfactory, and most municipal plants carry their softening operations to this point.

The method of softening to be used depends upon the character of the hardness of the untreated water, the amount of hardness permissible in the finished water, the cost of chemicals at the plant location and the disposal of sludge.

The zeolite and the lime-soda processes, or a combination of both, are the principal methods now employed for water softening. Where the greater part or all of the hardness is non-carbonate, or where it is desired to soften to zero hardness, zeolite is indicated. Zeolite is also indicated where the disposal of sludge is difficult or impossible. Where the greater part, or all, of the hardness is carbonate hardness and a 2 to 5 grain water is satisfactory, the lime-soda process is generally indicated. In all cases, however, a careful study of costs and conditions should be made before deciding upon the method to be used.

At Thomasville it was originally proposed to soften the water to 5 grains, or 85 p.p.m. hardness. By the lime-soda and zeolite methods, the costs per million gallons were estimated as shown in table 1.

On the above basis, the total saving, using the lime-soda process, would be approximately \$1400.00 per year. When actual contracts for chemicals were completed, however, it was found possible to obtain these materials at much lower prices than those given in the above estimate. The lime-soda method also lowers the concentration of minerals in the water while the zeolite method does not. Already in the small zeolite plant operated to prepare the boiler water for the municipal plant, the City is realizing a saving of about \$2.00 a day in salt consumption.

TREATMENT METHODS

Until quite recently, it has not been possible to decrease the carbonate hardness of lime-soda softened water below 50 to 60 p.p.m and this has been due principally to the fact that the magnesium could not be entirely precipitated.

Much work has been done in attempting to lower the final carbonate hardness of lime softened water. It was known that overtreatment with lime would accomplish this, but it remained for J. M. Montgomery, Superintendent of the Piqua, Ohio, plant, to work out the method on a full plant scale for reducing the carbonate hardness almost to the point of calcium carbonate solubility (about 17 p.p.m.). This was accomplished by over-treatment with lime to 40 p.p.m. caustic alkalinity, followed by re-carbonation, to convert the caustic

alkalinity to carbonate alkalinity and then filtration, to remove the carbonates. By this method practically all the magnesium was precipitated and the final carbonate hardness was consistently less than 30 p.p.m. This is the method used at Thomasville and detailed results during the various stages of treatment will be discussed later in this paper.

DESCRIPTION OF THE PLANT

The softening plant consists of two mechanical agitators, one clarifier, three carbonating chambers, one settling basin, two gravity filters, all constructed of reinforced concrete, and a three story brick and reinforced concrete building.

The untreated water is pumped from the wells to the two rectangular mechanically agitated mixing tanks and enters through 8-inch openings at the bottom of these tanks at the sides, thus imparting to the water an initial peripheral velocity. Lime is added in one mixing tank and soda ash in the other. The tanks are normally operated with a split feed arrangement and, at the same time, in series. That is, the lime tank takes a portion of the water, the soda ash tank the balance, plus the portion from the lime tank. A parallel operation can also be accomplished. The mixing period at 1.5 m.g.d. rate is 34 minutes, with a velocity of one foot per second. Water is drawn off at the top near the center of the tanks. From the mixing tanks, the water flows to a Dorr Clarifier which provides a sedimentation capacity of one and a half hours at normal rate. About 95 percent of the precipitated material settles out in the clarifier. The mechanism is operated about two hours daily, after which the sludge is drawn out by cracking the drain valve. This operation wastes approximately 5000 gallons daily. From the clarifier, the water flows over a weir into a collecting flume where aluminum sulphate is added, and then is led to the carbonation chamber that is located at the influent end of the sedimentation basin. Carbon dioxide gas is applied here to convert the excess causticity to the insoluble carbonate form and soluble bicarbonate form. The water then passes through the 4 hour sedimentation basin where the precipitate is allowed to settle, being assisted by the aluminum sulphate previously added. From the sedimentation basin, the water flows through a second carbonation chamber (which, at present, is not used) to the two conventional gravity filters of $\frac{3}{4}$ million gallons capacity each, when operated at two gallons per minute per square foot of sand area. The water is then passed through a small carbonation chamber, where carbon

dioxide gas is introduced to secure stability and, after this final treatment, the water flows to the present clear well.

Chemical feed

All chemicals are purchased in bags, in carload lots, and are conveyed by an electric elevator to the third floor of the plant, where the charging hoppers of the dry feed machines terminate.

The three dry feed machines for handling quicklime, soda ash and aluminum sulphate are located on the second floor. Fifty-eight percent soda ash and 17 percent alum are used. Ground quicklime, passing a ½-inch screen, is used and has 96 percent CaO content. The cost of this material per ton is less than hydrated lime and, because of its greater calcium oxide content, it effects a saving of approximately 30 percent over the use of hydrated lime. When handled in jute lined bags, it is no more inconvenient to use than hydrated lime. Loss from air slaking is negligible where storage does not exceed six weeks.

Slaking of the quicklime is accomplished in a simple and effective continuous slaker, consisting of a dry feed machine discharging directly into a solution hopper equipped with an agitator. The temperature in the slaker is controlled by the amount of water passing into the slaker.

Carbon dioxide equipment

Carbon dioxide is obtained from the power house stack. A wet and a dry scrubber are located at the stack and the suction pipe is connected to the breeching near the stack. An Ingersoll-Rand compressor, having a capacity of 100 cubic feet per minute, is located in the softening plant which is about 200 feet from the scrubbers. This compressor takes its suction from the scrubbers and discharges the gas into the two carbonating chambers. The compressor operates at constant speed and any change in carbon dioxide requirement is made by regulating an air dilution valve located at the compressor. The wet scrubber uses untreated water from the deep wells at about 12 gallons per minute, all of which is wasted.

Wash water and auxiliary water

There is a 50,000 gallon elevated wash water tank, which is filled by a 200 g.p.m. motor driven centrifugal pump. It is arranged so that either treated or untreated water can be pumped to this tank. At

present, untreated water is used for washing purposes. Likewise, untreated water is used in the dry feed machines and as cooling water for the compressor, but this is turned into the mixing tanks and so is not wasted as is the wash water, water for sludge removal and scrubber water. (Approximately 6.6 percent of the untreated water pumped is wasted in plant operation.)

Laboratory control of operation and results

The laboratory on the second floor of the main building is equipped to run all the necessary control tests connected with the lime-soda

TABLE 2

Alkalinity control data

	RANGE	OPTIMUM
Station No. 1 (Outlet to the Clarifier):		
Phenolphthalein Alkalinity	50 to 60	55
Total (Methyl Orange) Alkalinity	60 to 80	70
Resulting Causticity	35 to 45	40
Station No. 2 (Near Influent End of Settling Basin):		
Phenolphthalein Alkalinity	20 to 25	22
Total (Methyl Orange) Alkalinity	45 to 55	50
Bicarbonate Radicle	4 to 6	5
Station No. 5 (Finished Water):		
Phenolphthalein Alkalinity	4 to 8	6
Total (Methyl Orange) Alkalinity	28 to 32	30
Bicarbonate Radicle	16 to 20	18
pH values	8.4 to 8.7	8.6

All values (except pH) in p.p.m.

process of water softening. Here charts are kept for ready use, showing the required dry feed machine settings for the various rates of flow, the alkalinity-pH relationship curves and a few other charts that help the operator in his work.

Recent detailed studies of daily runs indicate that the alkalinities to be found at three of the five major control points to give a final 4 grain hardness are as shown in table 2.

The non-carbonate hardness, as obtained during the same time, was about 38 p.p.m. This, added to the total alkalinity, gives a total hardness in the finished water of 68, which was checked in the laboratory by the soap method.

To be sure that the routine laboratory methods used at the plant were giving reasonably true results, independent analyses of the raw and finished water were made and the results were checked against tests made in the plant laboratory. A comparison of the two tests is given in table 3.

The water leaving the filters has a pH value of 9.1 which, for an alkalinity of 30, is too high for stability. In order to lower the pH and insure stability, a small amount of carbon dioxide gas is added in the final carbonation chamber, as previously mentioned.

TABLE 3

Comparison of tests

	INDEPENDENT ANALYSIS		PLANT ANALYSIS	
	Raw	Finished	Raw	Finished
Phenolphthalein Alkalinity	0	5.6	0	6.0
Total Alkalinity as $CaCO_3$	129.8	31.7	130.0	30.0
Total Hardness	194.5	68.3	198.0	67.6
Non-Carbonate Hardness	68.7	36.6	70.0	40.0

Operating personnel

The operation of a lime-soda softening plant is somewhat more difficult than the operation of the usual water filtration plant. This is especially true where the water to be softened is obtained from surface sources where rapid changes in turbidity and hardness occur. Where these factors are constant, however, and where the plant can be operated at a fairly constant rate, as at Thomasville, efficient operation can be obtained by training the usual type of non-technical man available, with only occasional technical supervision.

Cost of operation

The plant has now been operating for three and a half months. The total cost per million gallons for the month of January is given in table 4.

The average reduction in hardness for the month of January was about 7½ grains.

SAVING DUE TO SOFT WATER

The economic advantage of municipal water softening is evident when the saving in soap, saving in repair bills for water services and

appliances, due to incrustation, and the saving in salt in existing zeolite plants, is balanced against the cost of softening. The saving by which the customers will be benefitted is shown below. The soap saving is based on the use of 0.1 pound of soap per part per million of hardness removed per 1000 gallons and the use of 3 gallons per person

TABLE 4

Costs of operation (in dollars)

Lime	10.21	
Soda ash	3.80	
Aluminum sulphate	0.82	
Total chemical cost		14.83
Water (washing and miscellaneous)		1.97
Power		2.92
Labor		6.05
Supplies and oil		0.14
Interest on investment		8.91
Depreciation		4.23
Total operating cost per million gallons		39.05

Cost per 1000 gallons—3.905 cents.

daily for bathing and laundering. The saving in the repair bills is estimated at $3.50 per service per annum.

	per year
Estimated saving in soap consumption	$25,500.00
Estimated saving in repair bills	7,000.00
Actual saving in salt consumption at the industrial and municipal zeolite plants in the City	1,825.00
Total saving	$34,325.00
Operating Cost	11,000.00
Total net saving to the customers	$23,325.00

In addition to this financial benefit, the personal comfort and convenience is to be considered which the community derives from the use of what is classed as soft water.

The writer wishes to express his appreciation to Mr. D. Rhett Pringle, Superintendent of Water and Light, Thomasville, Georgia, for the data furnished and the many courtesies rendered in the preparation of this paper.

(Presented before the Southeastern Section meeting, March 23, 1932).

DISCUSSION

Mr. Pringle:[1] With reference to saving by softening water, I have in mind two small institutions in our town which are saving $1200 a year alone on that water. In addition, the municipal power plant has a saving of about $800 a year.

On account of the economy of operation, we have been able so far to absorb the additional costs and not increase the rates, and as time goes on our customers will appreciate the water more and more. They are already speaking very highly of it.

Instead of Mr. Cady thanking me for courtesies in Thomasville, we certainly want to state here that we believe the success of that plant is due entirely to our engineers, Wiedeman and Singleton, largely assisted by Mr. Cady.

Mr. McGrew:[2] May I speak just a minute as one of the customers? When this came up I happened to be on the city council there too, so I am doubly interested. Of course, there was some criticism in the council for spending any amount of money. At that time it looked as if we were spending money in the face of depression. People said, "Well, you are just like the ordinary council, you are wasting money and we don't know where it is coming from." There was a great deal of criticism, but since the plant has been in operation that has entirely disappeared. Everybody is satisfied at the results and feel that they are not losing money, but rather that they have gained in the end.

Mr. W. H. Weir:[3] It probably does not appear that softening of water has great public health value. However, we have made observations from this standpoint on some of the supplies in southern Georgia using hard water. The stoppage in pipes and other inconveniences of operation, cause costly difficulties with boilers and other pieces of industrial equipment. Due to unsatisfactory hard water, laundries and persons who do private laundering go to shallow wells for soft supplies. The softening of water puts these people on the city distribution system and keeps them from using the old shallow well which is dangerous and should be abandoned.

[1] Superintendent, Water Works, Thomasville, Ga.
[2] Thomasville, Georgia.
[3] State Department of Public Health, Atlanta, Ga.

I know of one case in southern Georgia, a town of some twenty thousand people, that has a very beautiful hotel which is very well patronized. This is a hard water town. The hotel has a shallow dug well, not over twenty feet from the building sewer and the hotel is supplied with this water. Several public buildings in this town have dug wells in the basements. Giving these customers soft water would eliminate the chances of water-borne diseases from these dangerous shallow wells and increase the output from the municipal water plant.

Mr. Henderson:[4] Laundries that use soft water claim that the clothes will stand just about twice as many washings if they are washed with soft instead of hard water. Mr. Cady in Thomasville can add about twenty thousand dollars more on the saving. When you realize forty dollars a million gallons only comes to four cents a thousand gallons, it is obvious that the average town can afford to adopt softening where they have a hard water.

Another point that may be of interest in the increase of consumption following the use of soft water. Very likely that increase in consumption with the corresponding increase of revenue to the city will largely offset the cost of softening. Have you any information on that?

Mr. Cady: I will have to refer to Mr. Pringle on that.

Mr. Pringle: We have prospects and good ones, but I do not believe the increase in consumption will come until the next President is elected. We do have one big industry there which is going to pay as soon as economic conditions will permit.

We are happy to say that our revenue has shown no decrease. It has shown a slow increase, which we consider is very good.

[4] State Department of Public Health, Atlanta, Ga.

THE CHEMISTRY OF WATER SOFTENING

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The purpose of this paper is to present a brief elementary explanation of the chemistry of water softening. The excess lime method of water softening is becoming popular and because of its simplicity more should be known about it.

Water softening is simply the partial removal of excess quantities of calcium and magnesium constituents in water in order that the water may be made more suitable for laundry, boiler and general domestic use. It saves repairs in household heaters and lessens fuel bills. The softening process removes algae tastes and odors and makes a very palatable water.

There are two types of hardness, one called "temporary" consisting of the bicarbonates of calcium and magnesium which can be removed by boiling, and the second called "permanent" hardness due to the sulphates and chlorides of calcium and magnesium.

Before the right amount of chemicals can be added to water a "boiler analysis" should be made. This consists in testing for calcium, magnesium, alkalinity, sulphates and chlorides. A complete mineral analysis is not necessary.

The next step is the reduction of the results to a comparable basis. Since the molecular weight of calcium carbonate is 100 and the degree of hardness is expressed in terms of calcium carbonate all constituents are converted to that basis. For instance, 80 parts per million of calcium becomes 200 parts per million as calcium carbonate, etc.

When all the tests have been reduced to a common basis they are arranged in positive and negative columns in order of the electromotive series. For instance, in the positive column calcium comes first followed by magnesium. On the negative side the order is alkalinity, sulphates, and chlorides.

Hypothetical combinations, though scorned by many chemists, are very helpful in water softening work. The calcium first com-

bines with the alkalinity. Whichever is left over then combines with the next lower and so on to the bottom.

The following table gives reported analyses, analyses calculated in terms of calcium carbonate and hypothetical combinations for an assumed case.

	REPORTED	CALCULATED AS $CaCO_3$	HYPOTHETICAL COMBINATION
Ca	80	200	$Ca(HCO_3)_2 = 200$
Mg	24	100	$Mg(HCO_3)_2 = 50$
HCO_3	305	250	$MgSO_4 = 50$
SO_4	96	100	$Na_2SO_4 = 50$
Cl	70	100	$NaCl = 100$

Results in parts per million.

To calculate the amount of chemicals required to soften water it is necessary to indicate how lime and soda ash react with the various salts of calcium and magnesium.

The following chemical equations give the fundamental reactions of lime and soda ash from which the actual quantities of chemicals used in water softening can be accurately determined.

Temporary hardness

(1) $Ca(HCO_3)_2 + Ca(OH)_2 = 2CaCO_3 + 2H_2O$

(2) $Mg(HCO_3)_2 + 2Ca(OH)_2 = Mg(OH)_2 + 2CaCO_3 + 2H_2O$

In equations 1 and 2 the alkalinity, $Ca(HCO_3)_2$ and $Mg(HCO_3)_2$, reacts with lime, precipitating out all the calcium and magnesium except for a small percentage remaining in solution.

Permanent hardness

(3) $\begin{matrix} CaSO_4 \\ \text{or} \\ CaCl_2 \end{matrix} + Na_2CO_3 = CaCO_3 + \begin{matrix} Na_2SO_4 \\ \text{or} \\ 2NaCl \end{matrix}$

(4) $\begin{matrix} MgSO_4 \\ \text{or} \\ MgCl_2 \end{matrix} + Na_2CO_3 + Ca(OH)_2 = Mg(OH)_2 + CaCO_3 + \begin{matrix} Na_2SO_4 \\ \text{or} \\ 2NaCl \end{matrix}$

In equation 3 soda ash removes calcium non-carbonate hardness, but in 4 both soda ash and lime are required to remove magnesium non-carbonate hardness.

When magnesium is present it is best to add 40 p.p.m. excess lime to bring about a sharp precipitation. This gives the name to the

"excess lime" method of softening. Carbon dioxide if present reacts with lime and it is usually removed prior to addition of lime.

A perusal of these equations shows:

1. The lime required is equal to the magnesium plus the alkalinity plus the excess lime (usually 30 to 40 p.p.m.)
2. The soda ash required equals the non-carbonate hardness.

All of these quantities are calculated on the basis of calcium carbonate with a molecular weight of 100. These quantities are reduced to the chemicals themselves by their ratio of reacting molecular weights to calcium carbonate, corrected for per cent purity and converted to pounds per million gallons.

Excess lime is removed by addition of carbon dioxide after the major portion of the original lime floc has been removed. The reaction is as follows and must not be carried beyond 4 or 5 parts per million excess causticity remaining,

$$Ca(OH)_2 + CO_2 = CaCO_3 + H_2O$$

This floc is then removed and a second carbonation is applied to convert the remaining lime to calcium bicarbonate according to the equation:

$$Ca(OH)_2 + 2CO_2 = Ca(HCO_3)_2$$

The final product must not contain sufficient carbon dioxide in relation to the alkalinity to become corrosive. Waters not treated by the excess lime method or recarbonated contain carbonates which coat up pipes in the distribution system greatly affected their carrying capacity.

With the lime-soda ash process a water can be reduced to 40 to 60 p.p.m. hardness. By means of the excess lime method the hardness can be reduced to 20 p.p.m., if necessary.

Generally speaking lime is the cheapest chemical and if the removal of the temporary hardness lowers the total hardness to the desired limit, 75 to 125 p.p.m., then soda ash is not added. The degree to which water is softened for any particular case depends upon the economical analysis of what different removals can be secured for and what standard waters in the vicinity carry.

Another method of water softening suited for small installations, for water high in non-carbonate hardness and where water of zero hardness is required is known as the zeolite process. Zeolite is an arti-

ficial sand containing sodium zeolite. On filtration there is an interchange of calcium and magnesium in the water with sodium in the zeolite. When the interchange capacity of the filter has been reached the filter is put out of operation and is backwashed with a sodium chloride solution. The sodium replaces the calcium and magnesium in the zeolite restoring it to its original condition and the calcium and magnesium chlorides are discharged into a sewer. The degree to which removal of hardness is carried depends upon the rate at which the water is filtered.

One plant, Findlay, Ohio, removes temporary hardness with lime and permanent hardness with zeolite treatment. In California soda ash is cheaper than in the east, being produced in Owens Valley, while zeolite is cheaper in the east than here. Consequentlythe promotion of the excess lime method with soda ash to remove permanent hardness is certain to follow.

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GEOLOGICAL CONDITIONS GOVERNING LOCATION, DRILLING, AND CASING OF WELLS

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The geographical distribution of the areas in Illinois where deep wells furnish municipal water supplies is shown on figure 1 which is compiled in part from State Water Survey Bulletin 21. The northern area, which is by far the most important, embraces approximately one third of the total area of the State. In this portion of the State deeper wells obtain their water from the St. Peter, New Richmond, Jordan Dresbach, and Mt. Simon sandstones at depths ranging from 585 feet for the Dresbach at Rockford to 2800 feet for the Dresbach at Oglesby.

Within the northern area where Pennsylvanian strata cover the older formations it is not uncommon to obtain a water which is highly mineralized and contains objectional quantities of hydrogen sulphide.

The southwest area includes Randolph and Alexander and parts of Monroe, Perry, Jackson, Union, and Pulaski counties where water wells are 300–600 feet deep. In this area water is obtained from sandstones of the Chester series, which are Upper Mississippian in age, and from Lower Mississippian limestones. Inasmuch as these water-bearing formations are more limited in their areal distribution than are the St. Peter sandstone and lower aquifers in the northern part of the State, the quantity of the water derived from them is necessarily less.

In three other areas in Douglas, Clark, and Clinton counties the bedrock strata yield water in sufficient quantities for municipal use. The areas in Douglas and Clark counties are on the axis of the LaSalle anticline and water is obtained from Devonian limestones at a depth of 200 to 250 feet. The village of Trenton, in Clinton County, has several wells in the Pennsylvanian sandstones which furnish an adequate supply of water. The wells are from 220 to 240 feet deep and in a few instances penetrate as much as 100 feet of sandstone.

AREAS OF BEDROCK WATER SUPPLIES

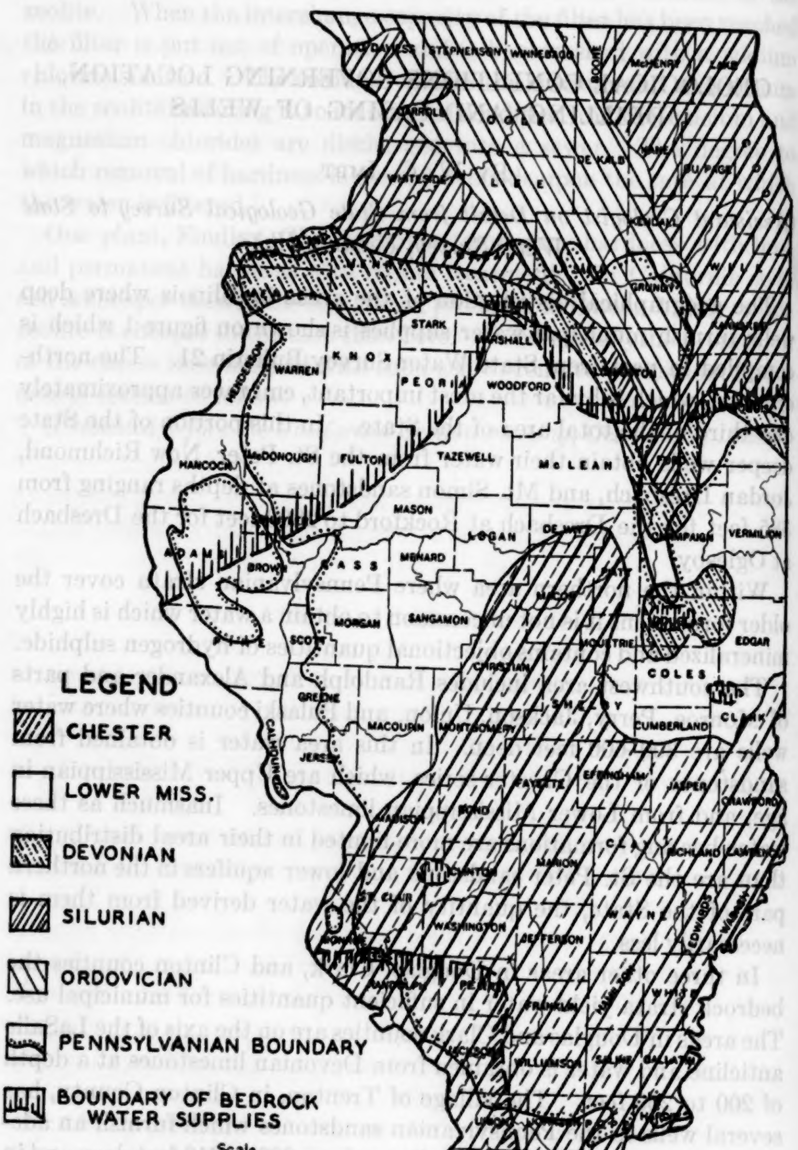

FIG. 1

AREAS USING WATER FROM WELLS IN SAND AND GRAVEL

Water supplies derived from bedrock formations in areas that lie within the Illinois Coal Basin are much inferior in quality to those available in areas where the older rocks crop out or lie concealed beneath a mantle of glacial drift. In areas where it is impossible to secure satisfactory water from deep rock wells, glacial deposits of water-bearing sand and gravel, in many places, may be located and tapped. Where sand and gravel deposits do not occur, municipalities must resort to surface water supplies.

GLACIAL DEPOSITS

There are numerous types of glacial deposits which are very important as ground water reservoirs. Probably the most important are valley-trains, because of their thickness, extent, and common occurrence. They represent gravel and sand fillings in existing or former valleys. Peoria and Pekin obtain their entire supplies from the valley-train deposits in Illinois River valley.

At Sullivan, Clinton, and Princeton, the municipal supplies are obtained from old valley-trains that have been entirely buried and are concealed by more recent deposits of glacial drift.

Another important type of glacial sand and gravel deposit is the outwash-plain. Outwash-plains are widespread deposits which were formed along the front of the glacier. These deposits of gravel and sand range in thickness up to about 100 feet. The water for Mattoon is secured from such a deposit which is 20 feet thick at the north and thins out to the east, south, and west.

Other types of glacial sand and gravel deposits which may locally yield an adequate water supply are: (1) Eskers, which are narrow sand and gravel ridges some 20 to 40 feet high and may be several miles in length; and (2) deltas, which have been deposited in lakes by waters heavily laden with glacial débris. These deposits are smaller than valley-trains or outwash-plains, and even where they lie buried below the water-table they may or may not furnish an adequate supply of water to large consumers.

In the central part of the State, where potable water from rock wells is not available, the discovery of buried valley-trains, which would yield abundant quantities of water, would directly influence the public welfare. With the increasing amount of geologic data at hand and the perfection of geophysical instruments for prospecting, the

problem of ascertaining the distribution, extent, and importance of individual buried sand and gravel aquifers is gradually being solved.

DRILLING CONDITIONS

The blanket of glacial drift, which covers a large part of the State, ranges in thickness from a few to more than 300 feet. Glacial drift is a heterogeneous mixture of clay, sand, gravel, and boulders in varying proportions. The drift presents no troublesome problems in the drilling of a well with the possible exception of an occasional crystalline boulder which must be either drilled through or shattered with dynamite. In a few wells in the vicinity of Chicago quick-sand has caused some difficulty in drilling.

The Pennsylvanian bedrock strata present no unusual difficulty to well drilling. For the most part they are composed of interbedded black to gray shales, sandstones, limestones, and coals. The maximum thickness attained by these strata in the northern part of the State is about 760 feet. Some of the shales and underclays in the Pennsylvanian system swell or disintegrate when wet, but few of them cave to a troublesome extent.

The Mississippian rocks, where present, are composed of limestones, cherty limestones, shales, and sandy shales. The members of this system do not cave to a great extent and therefore present no particularly troublesome problems in drilling. The Burlington-Keokuk limestone, which is *Middle* Mississippian, is typically a massive, coarsely granular, light gray, crinoidal limestone. In the upper part an abundance of irregular cherty layers occur, which may be thin plates or masses a foot or more thick. The effect of the chert on drilling is apparent in that the progress is slowed down by slow cutting and frequent dressing of the bits.

The Devonian rocks consist of brown and black shale, shaly limestones, and dolomites and offer no unusual drilling difficulty.

The Silurian system, which includes the "Niagaran" limestone, presents no problems in drilling other than that its joints and fractures tend to deflect the hole from the vertical, as will be discussed later.

The Maquoketa shale is easily drilled where it is a true shale, but northwest of Chicago it is composed of alternating layers of shale and dolomite which usually drill very slowly. In places where the Maquoketa is a soft shale some difficulty is experienced in picking up

the drillings with the bailer. To remedy this condition sand and gravel are poured into the hole to reduce the plasticity of the shale.

The Galena-Platteville dolomite is solid throughout and causes no trouble. In places it is apt to be hard and highly crystalline which slows down the progress of drilling considerably.

The St. Peter sandstone offers many perplexing problems. Many strings of tools have been lost in the St. Peter as a result of the drillings packing in around the tools. Drilling goes on without apparently any difficulty until an attempt is made to withdraw the tools from the hole, at which time they are found to be stuck. During the short time that drilling is halted in preparation for withdrawing the tools, the loosened sand, which has been in constant agitation during drilling, settles down tightly around the tools and binds them in place. This situation may be avoided by cleaning out the hole frequently and thoroughly.

The Prairie du Chien Series, consisting of the Shakopee dolomite, the New Richmond sandstone, and the Oneota dolomite, presents no difficulty in drilling other than that where the upper surface of the Shakopee is irregular it tends to deflect the hole.

The Jordan sandstone, the Trempealeau dolomite, and the Franconia formation which is mainly a shaly sandstone, in some parts dolomitic, present no perplexing problems. The Dresbach sandstone, the Eau Claire formation, and the Mt. Simon sandstone similarly give no trouble or unusual difficulty to the driller. Locally the Mt. Simon sandstone may be rather hard 150 to 200 feet below its top, but in the main it is incoherent.

NATURAL HAZARDS IN DRILLING

In many wells it is desirable to place a layer of cement between the casing and the walls of the hole to prevent the passage of upper waters downward to deeper horizons. Difficulty is experienced when cementing is attempted in a formation which is highly creviced and fractured, like the "Niagaran" dolomite. The systems of joints and fractures in this formation have wide lateral extents and thereby form a grid of fractures into which large amounts of cement may escape.

Most rocks, especially the more massive limestones and dolomites and to a less degree sandstones, are traversed by systems of joints and fractures. Drilling tools have a decided tendency to follow crevices in such highly fractured formations. The "Niagaran dolomite" is a

good example of creviced dolomite which is very apt to cause deflection of the tools while drilling so that a crooked hole is thereby developed. For example, during the construction of an intercepting tunnel at a depth of 357 feet to connect a number of wells at Argo, it was found that at this depth the wells deviate 6 inches to 11 feet away from the vertical. The maximum deviation amounts to one foot for every 32 feet of hole.

Soft shale tends to wad up around the bit and prevent turning of the tools in the hole. Thus the bit will soon "keyseat" and the net result will be a crooked hole in which it might even be impossible to run casing.

GEOLOGICAL CONDITIONS INFLUENCING METHODS OF CASING

Where formations tend to cave and squeeze, thus partially closing the hole, casing is necessary, as illustrated in figure 2.

The glacial drift is always cased off in the construction of deep wells. In some instances it is necessary to case the well as rapidly as drilling advances in order to prevent the upper portion of the hole from caving on top of the tools. In some places the glacial drift is sufficiently firm that the walls of the hole will stand up without casing. If the distance to bedrock is not too great where this condition prevails, the hole is allowed to remain open and casing is not set until solid rock is reached.

Although most of the Pennsylvanian rocks offer no unusual difficulties to well drilling because the shales, sandstones and clays of the Pennsylvanian do not cave excessively, a "tight string" of casing is always placed through the entire thickness of these formations to exclude undesirable waters.

In the northeast part of the State there is an increasing tendency on the part of engineers to case off all waters above the Galena-Platteville dolomite. This is a precaution taken to exclude the waters of the Niagaran which are subject to contamination from surface sources.

The Maquoketa shale is cased to prevent caving in the hole and it also serves as an effective seal against the passage of upper waters into the lower horizons. Where the formation is thin or where it is composed of alternating beds of dolomite and shale, little trouble with caving is experienced and the well is usually left uncased.

At the base of the St. Peter sandstone there occurs a conglomerate, composed of residual pieces of chert, sandstone, dolomite, and shale, which is cased into the top of the solid rock below to prevent caving and filling of the hole.

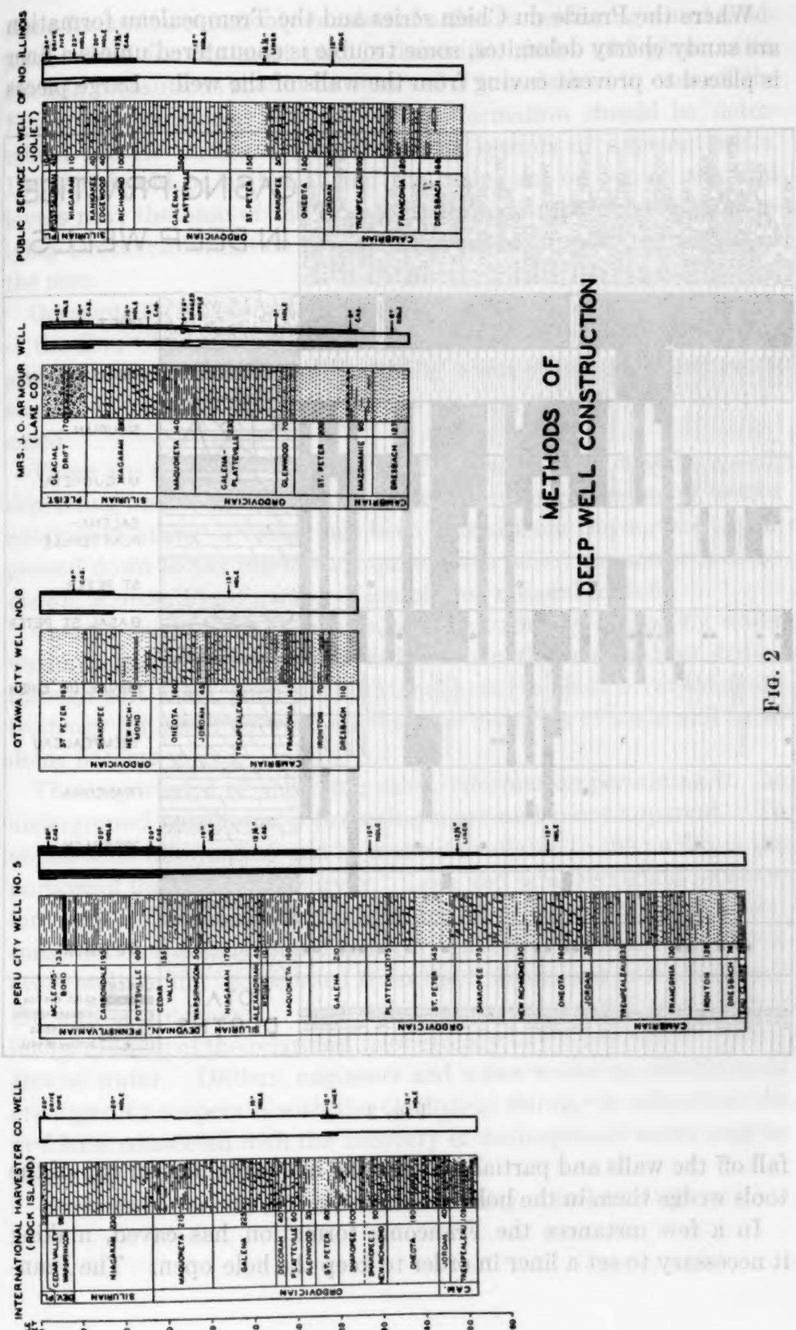
METHODS OF
DEEP WELL CONSTRUCTION
PUBLIC SERVICE CO. WELL OF NO. ILLINOIS (JOLIET)
MRS. J. O. ARMOUR WELL (LAKE CO.)
OTTAWA CITY WELL NO. 6
PERU CITY WELL NO. 5
INTERNATIONAL HARVESTER CO. WELL (ROCK ISLAND)

FIG. 2

Where the Prairie du Chien series and the Trempealeau formation are sandy cherty dolomites, some trouble is enountered unless a liner is placed to prevent caving from the walls of the well. Large pieces

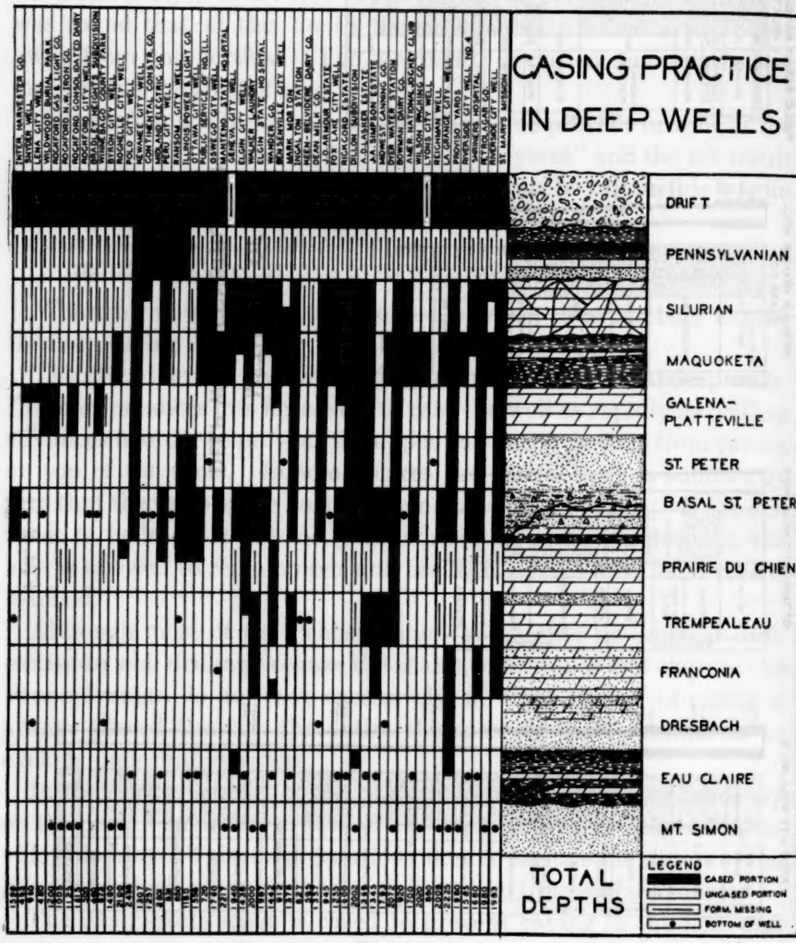

FIG. 3

fall off the walls and partially bridge the hole or falling on top of the tools wedge them in the hole.

In a few instances the Franconia formation has caved, making it necessary to set a liner in order to keep the hole open. The Fran-

conia formation commonly consists of a fine to medium-grained sandstone which for the most part is dolomitic, shaly, and glauconitic. Certain precautions should be observed if it is desired to case off the Franconia sandstone. The top of the formation should be determined and its thickness computed from records of adjacent wells. Drilling should be halted at and the casing set on one of the firm layers near the base of the Franconia formation because the underlying Dresbach formation is too incoherent to support the weight of the pipe.

Occasionally it is found necessary to place a short liner at the top of the Eau Claire formation. In the main the Eau Claire is a fine-grained, dolomitic sandstone, including layers of red, gray, and green shale. In most localities the shales are firm enough to be left uncased.

There are a number of ways (fig. 3) in which wells may be cased, depending on the geological conditions. In a large number of wells a continuous string of casing has been placed from the surface of the ground down to the top of the aquifer from which the water is to be drawn, in order to get a water of a preferred mineral content.

Casings are also set to reduce possible turbidity caused by water washing against the walls of the well. Where the hole has been drilled through soft shale, such as the Maquoketa, there is a very definite tendency for water to wash off the finer particles of shale and in so doing become turbid.

The importance of collecting exact information pertaining to the underground conditions is becoming more and more apparent. To obtain such information and to make it available to the public, is the purpose of the Geological Survey. Logs and samples should be saved for every well drilled. A complete record of casing installation and constructional details should be kept. In short, a complete history of every well should be recorded from the time drilling is started until the well is abandoned. Such information is essential to a perfect understanding of the relationship of geology to the recovery of underground water. Drillers, engineers and water works superintendents are urged to coöperate with the Geological Survey in order that the problems connected with the recovery of underground water may be more fully understood.

(*Presented before the Illinois Section meeting, April 19, 1933.*)

TREATMENT OF WATER FOR INDUSTRIAL PURPOSES

By J. O. Meadows

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In the past, industries put up with indifferent water supplies just as municipalities did and, in most cases, their products suffered in consequence. Sometimes it would happen that a competing industry would have a suitable natural water supply and because of it would be able to turn out a product of superior quality. In time, the competing firms would find out that their competitor's higher quality product was largely due to a superior quality water supply, which would start them off to improve their own water supplies so that they in turn could better their product and thus be in line to compete successfully for the business offered.

The intention of this paper is to confine the subject matter to such industrial water supplies with which we have had actual experience or rather close association. Water supply for boiler feed, in itself a large subject, is not included. However, before dismissing boiler feed water supply completely, mention should be made of the growing tendency towards external treatment of the feed water supply. With the increased practice of higher boiler pressures the internal treatment of feed water is not applicable and the external treatment is gaining ground.

Paper mills making newsprint do not required very much treatment for their water supplies. Some of the mills have water supplies that they can use without treatment, others pass the water through revolving screens having about 60 mesh per inch. These screens are cleaned by a jet of water under presure and they remove coarse matter in suspension which would give trouble in the paper stock and lower the grade of the paper. Other newsprint mills filter their water through gravity or pressure filters without the use of a coagulant. When so used the filters simply act as strainers, removing a large percent of the total suspended matter present. Mills making bleached kraft and high grade papers require a water practically free from suspended matter, together with a low color content. Un-

less the color is reduced to a low figure, the bleached pulp absorbs the color from the water during the washing process and the grade of the product is lowered. These mills usually purify their water supplies by means of rapid sand filtration, using a coagulant to effect the desired degree of clarification. The water turned out by some of these plants would compare very favorably with the product furnished by some of the municipalities treating their water in a similar manner.

Recently a paper mill desiring to produce a higher grade product and not wishing to incur the capital cost of a rapid sand filter plant to remove the high color content has resorted to the use of chlorine bleach to effect color removal. Up to 200 pounds of chlorine per million gallons has been used and about 70 percent color removal has been effected. A higher color removal would be desirable, but the amount so far obtained has resulted in securing a paper of improved quality.

Cellophane production requires a water of good physical appearance together with low mineral content. The location by Canadian Industries at Shawinigan Falls was partly due to the soft character of the water supply obtained at that point. The water for the plant is filtered through rapid sand filters using alum as a coagulant and is then suitable for plant use. Had the water not been soft it would have been necessary to provide a Zeolite softener.

Textile mills, especially those dealing with silk, wool, rayon and celanese require a water of good physical characteristics together with a softened water for some of their processing. These mills usually clarify their water supplies with rapid sand filters and soften with Zeolite softening units. A water supply that it is not suitable, interferes greatly with the washing, dying and tin weighting of the product.

The brewing of ales generally requires a fairly hard water, one with a fairly high sulphate content being generally preferred. When the water is not naturally suitable, it is made so by the addition of ground gypsum, common salt and other chemicals.

Breweries receiving surface water supplies sometimes experience considerable trouble in the fermentation process due to bacterial growth induced by organic matter present in the water supply during certain periods of the year. During such periods the natural yeast fermentation of the wort is interfered with by the bacterial action induced by the organic matter present in the water supply. This

condition is remedied by filtering the water supply with rapid sand filters, generally using alum as a coagulant.

Those of you who know how difficult it is to produce a water with a very low suspended solids content, especially when the water is to be held for several months before being consumed, can appreciate some of the troubles of the high grade carbonated beverage manufacturer.

Some of the coagulant treated waters if held a sufficient length of time will show an after precipitation. Such a water generally passes muster, but when used by a carbonated beverage manufacturer to produce plain soda, trouble occurs. Some of the product is not consumed until months after production with the result that the carbonated water has a poor appearance and numerous complaints follow. In dealing with a water for carbonating purposes where it is proposed to use a coagulant for clarifying purposes, the water must be treated with several different chemicals, must then be carbonated and held for several months so as to be sure that no after precipitation occurs.

Infection of carbonated beverages by wild yeast is not common, but occurs. A carbonated beverage manufacturer using a well water pumped by air lift experienced such trouble in his beverages containing sugar solutions. Examination and tests indicated that the yeast was gaining access to the product through the water supply and that the wild yeast was getting into the water from the air. The air compressor was supplied with a standard air filter, but this was not sufficient to effect the desired degree of bacterial purification, and not until a second air filter, composed of several separated layers of cotton was installed, could satisfactory results be obtained.

It is sometimes necessary to treat saline mineral waters before they can be carbonated and bottled for the trade.

One such water from a spring contains algae growth which continues to increase when bottled and greatly lowers its commercial value. This water is now being treated with sodium hypochlorite in storage and then filtered through activated carbon. The purified product will keep for months without showing deterioration.

Another saline water from a spring was heavily charged with carbon dioxide which liberated at atmospheric pressure and caused a rather heavy precipitation, a portion of which did not settle out readily. This water was treated with filter alum in the storage tanks, allowed to settle, and then passed through a Seitz filter.

A leather plant which tans and dyes skins experienced trouble following the introduction of an alum treated water into the municipal

water system. The water previous to treatment was corrosive, but the products of corrosion adhered to the sides of the water mains and practically no trouble was noted.

With the introduction of the filtered water trouble started due to the lower pH value of the water which tended to take iron into solution and also caused a loosening of previous corroded material. The iron in solution and in suspension caused dark streaks and specks on the skins and a great deal of trouble was experienced. To correct the trouble quick lime was applied to the filtered water with a dry feed machine. This treatment increased the pH value sufficiently to prevent corrosion and turn out a water having a lower iron content than the raw water.

Wineries sometimes experience trouble with their product due to the character of the water supply used in washing out vats and other receptacles about the winery. The trouble is usually due to a bacterial growth which causes the product to become turbid and develop a poor taste and flavor. A water supply causing this trouble must be very well purified bacteriologically and can be best handled by rapid sand filtration followed by chlorination. At the winery in question sedimentation, coagulation, filtration and chlorination was recommended as the proper procedure to be adopted to secure a water of satisfactory quality.

In the production of a refined milk sugar suitable for infant feeding, a product must be obtained with a very low bacterial content.

The milk sugar after being crystallized from solution is put in a centrifuge to remove excess water and while in this machine it is washed to remove impurities. The water used to wash the sugar must be of good quality both physically and bacteriologically because the sugar acts as a filter and retains bacteria and matter in suspension. As the quantity of water employed is small it can be best handled in storage tanks, treating the water with a coagulant if necessary, then filtering and finally treating the water with hypochlorite.

You are all familiar with chloramine treatment in municipal water supplies, so you will probably be interested in knowing something about its use in connection with slime growth in pulp and paper mills. Slime growth which occurs in the tanks, flumeways and other equipment in a mill, is due to the growth of capsulated bacteria. This troublesome growth lowers the grade of the paper stock, causes interruptions in machine operation, and increases the cost and frequency of mill clean-ups.

Previous to the application of chloramine to prevent slime growth, chlorine treatment was attempted with rather indifferent success. The chlorine was absorbed quickly and rather high dosages had to be employed to effect anywhere nearly satisfactory results. Chloramine is not used up as rapidly as chlorine; a longer contact is afforded and more satisfactory results are obtained. Chloramine treatment of the water supply of pulp and paper mills has already been successful in numerous cases and the treatment has resulted in effecting substantial savings. The effect of chloramine treatment can be gauged bacterially by plating portions of the treated mill water on special culture media for the growth of the capsulated organism. Typical colonies can then be examined microscopically when specially stained for capsulated organisms.

(*Presented before the Canadian Section meeting, March 22, 1933.*)

INTAKE PIPE AND JUNCTION SHAFT FOR TORONTO DUPLICATE WATER SUPPLY

By F. W. Douglas

(The Foundation Company of Ontario, Limited, Toronto, Canada)

The new duplicate water works system now under construction for the City of Toronto includes the following structures: An intake located in Lake Ontario, approximately one and a half miles southeast of Victoria Park, a submerged intake pipe line, junction shaft and tunnel from the intake to a shore shaft at the site of the new filtration plant, a filtration plant and pumping station at Victoria Park, a concrete lined tunnel from the East City limits to Sunnyside near the West City limits, about seventeen miles of large diameter steel and concrete pipe lines, a 50,000,000 gallon reinforced concrete reservoir at St. Clair Avenue and Spadina Road, and related works of minor importance.

This article is limited to the intake structure, intake pipe line and junction shaft now being constructed by The Foundation Company of Ontario, Limited.

The intake is located in 50 feet of water at a point 7,462 feet southeast of a shaft located on the shoreline at the site of the new pumping station at Victoria Park. A circular steel intake structure rests on top of a tee section which forms the end unit in the pipe line. From the tee section a pipe line 4,100 feet long and 8 feet inside diameter extends towards the shore in a northwesterly direction to join the intake tunnel. A butterfly valve eight feet in diameter is located between the inshore end of the pipe line and the outer end of a three-way distributor. The inner end of the distributor connects directly to the side of a caisson in which the junction shaft is located 3,300 feet from the shore shaft. The junction shaft forms the connection from the pipe at elevation 202.00 to the tunnel at elevation 143.27. The normal elevation of Lake Ontario is 246.00. The tunnel was completed under another contract before the construction of the intake pipe and junction shaft was started. The above brief outline is intended to show the relation of the various units making up the intake line. A detailed description of each unit follows.

JUNCTION SHAFT AND CAISSON

The construction of the junction shaft was carried out by sinking a steel caisson through sand and clay into the rock by the pneumatic method. After the caisson had been sealed with concrete at the cutting edge, the air pressure was released and the balance of the shaft and the lower elbow were excavated through the rock in the open and holed through into the existing tunnel.

The steel caisson for the junction shaft is 35 feet in diameter by 34 feet high. The working chamber, completely encased in steel had head room of 7 feet 6 inches above the cutting edge. The upper elbow for the junction shaft was also formed in steel and built into the caisson. Two 45-inch diameter working shafts passed up from the working chamber roof through the elbow to the top of the caisson, one of these being for the access of workmen and the other for handling the excavated material and concrete. The steel caisson was fabricated by The Toronto Iron Works at their Eastern Avenue plant and assembled by them at the Spadina Avenue yard of The Foundation Company of Ontario Limited. The lower section when completely assembled was picked up and placed in the water at the south end of the dock by a derrick boat. The upper section was also completely assembled on the dock and lifted by the derrick boat and placed in position on top of the lower part of the caisson. The steel elbow was then assembled in the caisson and the rivetting and caulking of the entire structure completed while floating. Before taking the caisson out to its final location in the lake, 115 cubic yards of concrete were placed in the caisson which filled the working chamber walls and about one foot thick over the roof. With this concrete placed the caisson was drawing approximately 17 feet of water which provided the necessary stability for towing.

On May 19, 1932 the caisson was towed out to the site of the work and placed in position. Concreting was immediately started and continued without interruption until completed on May 21, when a total of 873 cubic yards had been placed. The two working shafts on the caisson were then extended up 40 feet and air locks fitted to the top of each shaft. On May 31, 1932, all fitting up for compressed air was completed and excavation was commenced by the pneumatic method. This work was carried on continuously day and night until the cutting edge reached its final elevation of 178.00 on June 22. The material encountered in the excavation included sand,

gravel, clay and gravel with some boulders and the last four feet in shale rock. Initial air pressure in caisson was 15 and final pressure was 28 pounds per square inch. After the caisson was sealed and the air pressure released, the balance of the junction shaft was carried down in the open. The shale rock was broken up with pneumatic paving breakers, no explosives being used at any time. The shaft and lower elbow were excavated to a diameter of 13 feet and later lined with concrete to a diameter of 11 feet. A transition section, 15 feet long, joined the 11-foot circular section at the lower end of the lower elbow with the 10 foot horse-shoe section at the end of the existing tunnel. The lower portion of the junction shaft having been completed, that part of the steel roof of the working chamber under the elbow, and the two working shafts inside the elbow were burned out. The steel elbow was then lined with gunite to a finished diameter of 11 feet and the working chamber was filled with concrete, completing the shaft between the top of the rock and upper elbow. This completed the construction of the junction shaft with the exception of the installation of a permanent chrome nickel iron ladder, the burning out of the steel bulkhead between the upper elbow and the three-way distributor and the closing of the second working shaft which was left open until all work in the caisson is completed. The steel bulkhead is to be left in place until the butterfly valve has been placed and closed, permitting unwatering of the three-way distributor. This work is to be completed in the 1933 construction season.

THREE-WAY DISTRIBUTOR

The three-way distributor connects to the side of the caisson at the upper elbow having a finished inside diameter of 11 feet at this point, the other end branching out into three 8 feet inside diameter openings. Two of these openings are fitted with watertight bulkheads of oak timber reinforced with steel, these being for future pipe lines when additional supply is required. The south branch is used for the intake line now under construction. The distributor is on a foundation consisting of a concrete mat 3 feet thick, resting on wood piles. The steel work for the distributor was fabricated by The Toronto Iron Works and assembled at The Foundation Company's Spadina Avenue yard where the 2-inch gunite lining and heavy concrete encasement were placed. When completed, this unit weighing 235

tons was lifted from the dock where it was constructed, taken out into the lake and set in its final position by the derrick boat "Foundation Scarboro."

BUTTERFLY VALVE

To permit unwatering of the tunnel an 8-foot diameter butterfly valve is located between the three-way distributor and the first length of intake pipe. The valve is constructed so as to operate by means of a hydraulic cylinder mounted on a cast iron bracket attached to the body of the valve. Two make-up pieces are provided with flanges for bolting to the flanges of the valve body. The outer ends of these make-up pieces are provided with matching connections for the 8-foot opening in the distributor and the first length of intake pipe. The valve is to be placed during the 1933 construction season.

INTAKE PIPE

Extending in a southeasterly direction from the valve is the intake pipe line consisting of forty-one sections of pipe, each 100 feet long and 8 feet finished inside diameter. These pipes are constructed of steel plate lap welded in courses approximately seven feet wide. The end courses are $\frac{1}{2}$-inch plate, the middle courses $\frac{3}{8}$-inch plate and the balance are $\frac{5}{16}$-inch plate. The two ends of each pipe are provided with a half band of 12 by $\frac{3}{4}$-inch plate bent out at right angles at the centre of each side and connected to lug angles. These horizontal extensions have holes 3 inches in diameter. The bands are attached to the upper half on one end, and the lower half on the other end of the same pipe, thus forming matching connections for succeeding lengths of pipe, held together by 3-inch diameter taper steel pins in the 3-inch holes in the connection lugs. The steel pipes, fabricated in the shops of The Toronto Iron Works were delivered to The Foundation Company's yard in two 50 feet sections and there electrically welded into one hundred foot lengths. The pipe was then placed on saddles resting on wood bottom forms and outside reinforcing steel placed. Outside steel forms were then set and concrete poured forming a horse-shoe shaped outside encasement. Each pipe required 97 cubic yards of concrete. Inside reinforcing bars were then placed and 2-inch gunite lining completed on the interior. Each 100 foot section of pipe when completed weighed 250 tons.

The pipes were assembled and concreted on skidways constructed

of 12 by 12 timbers. Sufficient skidways were provided to accommodate 21 pipes. They consisted of two parallel skids placed at 49 foot centres bearing on 12 by 12 sleepers. The bottom forms for the pipe were constructed of wood in three sections, one section between the skids and one on each side to carry the overhanging ends of the pipe. These forms were supported on jacks bearing on concrete footings. The side forms were of $\frac{3}{16}$-inch steel plate.

A regular schedule of concreting two pipes per week was maintained on this part of the work and the entire 41 pipes were completed early in November 1932. When the pipes had been cured ample time for them to be self-supporting, the bottom forms were dropped and moved to the next pipe location. As the pipes were required for placing in the lake they were skidded down to the edge of the dock wall and there picked up by the derrick boat "Foundation Scarboro," taken out to the lake and lowered into their positions in the trench.

In transporting the pipe from Spadina Avenue yard to the site of the work in the lake, a distance of about seven miles, careful consideration was given to weather forecasts, as reasonably quiet water was necessary to carry out this part of the work. Frequently several days elapsed after a pipe bed had been prepared before wind conditions would permit safely taking out a pipe. Great precision was necessary in manoeuvring the "Foundation Scarboro" and mooring her into the exact position for lowering the pipe. Divers were stationed at the end of the pipe on the lake bottom and by the use of submarine telephones gave instructions as to shifting of the pipe in order to make the connection. The pipe trench was dredged to rough grade by the derrick boat "Leyland." The final trimming of the trench and preparing the gravel bed for the pipe was carried out by the derrick boat "Foundation Jupiter." Twenty-four pipes were laid during the 1932 season, leaving seventeen to be placed during 1933.

After a sufficient number of pipes had been laid, the pouring of concrete joints was commenced. The concrete poured at the joint completely encased the 24-inch length of exposed steel plate at each joint and extended a distance of 12 inches above, below and on each side of the concrete excasement of pipe. All submarine concrete was poured by the tremie method from a floating concrete plant on the steel scow "Foundation Fasolt" A portable belt conveyor driven by a gasoline engine handled the dry premixed aggregate from a scow pocket to a bin located directly above the mixer. The aggregate was fed by gravity into a mixer hopper where the cement was added and the batch dumped into the mixer.

INTAKE TEE

The Intake Tee is located at the end of the intake pipe line. It provides a connection between the intake pipe and the circular intake structure. It is 20 feet long and has an 8 feet diameter inside the 2-inch gunite lining. The outer end is closed with a steel plate bulkhead. An 8 feet diameter outlet on top is provided with flange for bolting the circular intake in place. The Intake Tee is constructed of $\frac{1}{2}$-inch steel plate electrically welded and has steel clips welded to inside and outside for connection of concrete reinforcing bars. The Tee was delivered to the Spadina Avenue yard completely assembled. The outer concrete encasement and interior gunite lining was then placed.

CIRCULAR INTAKE STRUCTURE

The circular intake structure is bolted to the opening in top of the Intake Tee. The intake is 20 feet in diameter. The top is reverse dished connecting to a central casting. The bottom is also reverse dished and connects to a circular opening, the connection telescoping into the outlet on top of tee and bolting thereto. The intake is divided into eight sections by vertical baffle plates. This furnishes eight rectangular openings arranged in a circle each opening being 4 feet high and 7 feet 10 inches wide measured along the arc. These openings are protected by vertical steel bars $2\frac{1}{2}$ inch in diameter spaced $15\frac{1}{2}$-inch centres and extending from top to bottom of openings. The entire unit is of rivetted construction and all plates are $\frac{5}{8}$-inch.

WORKING PLATFORM

During March, 1932, preliminary work was commenced in Lake Ontario at the site of the junction shaft where protection piling for the caisson was driven and a working platform consisting of a structural steel tower was erected to carry construction equipment. A plank platform was constructed on top of the tower which carried the following items of plant: A ten ton stiff leg derrick with a seventy foot boom; steam hoist and boiler; swinging engine; boiler feed pump; small steam driven electric generator lighting set; two electric compressors; two portable gasoline compressors and two air receivers. The hoist and compressors were protected by a wood housing on the west side of the platform and on the east side was located a change

house for the sand hogs, equipped with bath-tub, shower bath, hot and cold running water, electric lights, lockers, benches, etc. The sinking of the caisson and excavating and concreting of the junction shaft, described above were carried out from this working platform. Electric power for operating the air compressors, water, high pressure air and fire protection was furnished from the "Foundation Jupiter" which was moored alongside the platform during the entire operation of sinking the caisson.

FLOATING EQUIPMENT

The "Foundation Scarboro" which handled the 250 ton pipes and the 235 ton distributor, has a lifting capacity of 300 tons. The hull is of steel, 100 feet long, 42 feet wide and 11 feet 6 inches moulded depth. Twin shearlegs pin connected to permanent pedestals on the deck at the stern of the ship were designed particularly for handling the pipes on this intake contract. These shearlegs are designed for a lift of 150 tons each, and when not used, can be laid flat on the deck. The maximum lift is taken over the stern and is counterbalanced by ballast tanks, the ballast being transferred as necessary while the load is being handled. The deck house contains an operator's room, mess-room, galley, toilet, storehouse and Captain's cabin. Provision is made for the installation of a 30 ton revolving crane which will be mounted on top of the circular operator's room. Below decks, in addition to the ballast tanks and fuel oil tanks, are an engine room, crews' quarters and a large cargo hold for the storage of equipment. All machinery is electrically driven, primary power being furnished by two diesel engines each of 200 H.P. direct connected to 220 volt D.C. generators. The two main hoisting engines are single drum and motor driven through a combination of worm and spur gears. These engines are designed to eliminate friction clutches and loose or sliding drums, the load being lowered only by reversing the motors. Any tendency to creep under load is prevented by automatic solenoid brakes.

The motor ship "Foundation Jupiter" is a steel hull, diesel self-propelled derrick boat equipped with a 30 ton stiff leg derrick with a 70 foot boom. This boat was used during the erection of the working platform and the installation of construction equipment on same, and during the time the caisson was being sunk was anchored alongside the working platform. She was then engaged in trimming the pipe trench and placing the gravel bed for same. Two tug boats

"Foundation Margaret" and "Glenlivet" were used during the entire season towing equipment and material from Spadina Avenue yard to the site of operations in the lake. The steel scow "Foundation Fasolt," equipped as a concrete mixer boat was described previously. The 30 foot steel diesel motorboat "Foundation Mary" was used for running anchor lines, etc.

SUBCONTRACTORS

The Toronto Iron Works Limited supplied all the steel work in connection with the caisson, three-way distributor, intake tee, circular intake and forty-one lengths of intake pipe. The Ontario Ready Mix Concrete Limited supplied all the concrete poured at Spadina Avenue yard, and also furnished all the premixed aggregate and cement for concrete poured in the lake. Reinforcing bars were supplied by The Steel Company of Canada, Limited and the welded wire mesh by The Canadian Steel Corporation. All the reinforcing was placed by B. McDonald & Sons, Limited. The Disher Steel Construction Company, Limited, furnished the steel forms for the pipe. The structural steel for the working platform was supplied by The Dominion Bridge Company Limited. The eight-foot butterfly valve was supplied by Drummond McCall & Company, Limited, Canadian Agents for J. Blakeborough & Sons Limited, Brighouse, England, and manufactured for them in Canada by William Hamilton Limited, Peterborough, Ontario. Dredging of the trench for the intake pipe was executed by The Canadian Dredge & Dock Company Limited with their derrick boat "Leyland."

SUPERVISION

The work is being carried out under the direction of Mr. R. C. Harris, Commissioner of Works for the City of Toronto. Messrs. H. G. Acres and Company, Niagara Falls, Ontario, and Gore, Nasmith and Storrie, Toronto, are the consulting engineers. Mr. G. G. Powell, Deputy City Engineer, Mr. James Milne, Engineer of Water Supply and Mr. A. U. Sanderson, Assistant Engineer of Water Supply are taking an active part in the direction of the work under Mr. Harris. Mr. H. Smith is in charge of field operations and Mr. W. Parkhill is resident engineer for the Works Department.

Mr. R. E. Chadwick, President of The Foundation Company, devoted a great deal of study to the construction methods used on the work and was responsible for the design of the derrick boat

"Foundation Scarboro" which has so successfully handled the heavy pipe units. R. R. Holland Vice-President in charge of the Engineering Department and Walter Griesbach, Chief Engineer of The Foundation Company prepared the plans for the construction plant layout and details of construction methods. J. F. W. Blaiklock is Manager of The Foundation Company of Ontario Limited, W. U. Smick is Superintendent of construction in direct charge of the work and the writer, F. W. Douglas, is resident engineer on the work for The Foundation Company.

(Presented before the Canadian Section meeting, March 24, 1933.)

STEEL RESERVOIRS FOR LONG BEACH, CALIFORNIA

By Burt Harmon

(*Hydraulic Engineer, Long Beach Water Department*)

The plan of using a group of six steel tanks for a storage reservoir for the city of Long Beach was adopted as the solution of a problem that had economic, political, geological and seismic angles.

The hill on which the reservoir is built has been occupied by a small concrete structure for about 30 years. Plans for a conventional concrete lined earth-fill reservoir to replace the old structure were drawn several years ago. But unfortunately, from the standpoint of the Water Department, the reservoir site is a part of the Signal Hill oil field and a former city administration permitted the location of oil wells on the hill, three of which came within the lines of the proposed reservoir.

After several attempts to fit a design to what remained of the site, it was decided to build two thirds of the reservoir, and complete the structure when the oil wells were finally abandoned.

The formation of Reservoir Hill consists of a layer of sandy clay about 11 feet thick overlying a deposit of fine, dry, white sand. The possibility of difficulty with the foundations of the cross walls caused a change to a third design—a group of circular concrete tanks in place of a single large reservoir.

Meanwhile, in investigating a discrepancy in the elevations of certain city bench marks, it was found that there had been a settlement of Reservoir Hill of about 0.4 foot. A survey showed this settlement to extend over an area roughly oval in shape and about 3 by 5½ miles in extent with a maximum movement along the axis of Signal Hill in excess of 0.6. This settlement is undoubtedly due to the extraction of some 465 million barrels of petroleum from that area since 1921.

The discovery of this movement of the reservoir site impelled our consulting engineer to recommend the use of steel tanks in place of concrete. Steel tanks in the Los Angeles area have passed through fairly severe earthquakes with slight damage.

The construction of steel tanks has been fairly well standardized by the oil industry, most of the companies using the designs and specifications of the American Petroleum Institute. Our local manufacturers are equipped to turn out tanks of that type quickly and at a reasonable cost. Following the lead of the oil industry, therefore, the design for a standard 112,000 barrel tank was adopted for our use and modified to suit our requirements.

This standard tank is 132 feet in diameter and 46 feet high. It is built in eight courses 5 feet 9 inches wide and varying in thickness from $\frac{7}{8}$-inch at the bottom to $\frac{1}{4}$-inch at the top. The tank bottom is $\frac{1}{4}$-inch thick.

In preparing the foundations for the six tanks, a portion of the hill was graded from a maximum elevation of 206 feet down to elevation 170. The old reservoir was kept in commission until the first three tanks were completed and then removed to make room for the next three. In this grading operation, 93,000 yards of earth were removed and 19,000 more in the re-shaping and landscaping of the hill after the removal of the old reservoir.

Near the edge of the foundations, wherever the cut was in clay, this clay was excavated to a depth of 3 feet or more and backfilled with sand to form a homogeneous base. The center of each foundation was given a "crown" of 1 foot, the whole foundation forming a segment of a sphere.

The excavation was made with a power shovel, and the surface dressed first with a 60 h.p. tractor and McMillan Dirt Mover, then with a team and fresno, and finally finished and tamped by hand.

About 30,000 yards of earth were dumped adjacent to the excavation to form the foundation for other tanks to be built later. When the oil wells on the hill are finally abandoned, there will be room for a total of 31 tanks of the size of the ones already built, with a total capacity of 108 million gallons.

A. P. I. tanks are designed for a maximum tensile stress in the net section of the plate of 21,000 pounds per square inch. In order not to exceed the allowable maximum stress of 16,000 pounds the third and sixth courses from the bottom were omitted, giving a total height of $34\frac{1}{2}$ feet and a capacity of 3,460,000 gallons.

The thickness of the plates in the tank as constructed run $\frac{7}{8}$, $\frac{25}{32}$, $\frac{9}{16}$, $\frac{15}{32}$, $\frac{5}{16}$, and $\frac{1}{4}$ inch.

The four lower courses are double butt-strapped and the two upper courses lapped. The top is reinforced with a 3-inch angle, and

additional stiffness is secured by two tracks built to carry a painters trolley. These tracks are also of 3-inch angles and are fastened inside and outside one foot below the top angle.

The top ring is further secured by 10 tie rods that are fastened to the top of the middle roof column.

The inlet and outlet openings are 24 inches in diameter and are placed on opposite sides of the tank to promote circulation. The bottom of the discharge opening is 13½ inches from the bottom of the tank. This distance is fixed by the required size of the nozzle reinforcing plate.

The bottom of the tank is of ¼-inch plate and conforms to the spherical segment formed by the foundation. This "crown" is given the bottom in order to cut down the amount of unavailable water below the discharge and also to facilitate cleaning. An 8-inch cleanout line forms the only opening through the bottom of the tank.

Each tank is provided with an 18-inch overflow pipe with a 3 feet by 4 feet spillway funnel one foot below the top of the tank. This overflow pipe passes through the fifth course about 8 feet below the top and continues to the ground on the outside of the tank. Overflow and drain lines empty into a reinforced concrete drain line that serves all six tanks.

The outlet header is of 30-inch cast iron and is laid between the two rows of tanks. Inlet and outlet pipes are laid with cast iron below ground and steel above. Dayton type unions were placed in the steel sections for additional flexibility. Rising stem gate valves are placed at the tank on both inlet and outlet lines.

The roof is supported on T shaped columns, each column built up of a 9- and 10-inch channel. Purlins of 12-inch channels are riveted to the column caps. The rafters are 2 by 12 with a rise of 1½ inches per foot, with one inch sheathing. All wood is creosoted Oregon pine. The roof is covered with one layer of 85-pound mineral coated felt roofing.

ERECTION

In the erection of the tanks, the bottom is assembled and riveted on a support about 3 feet above the ground. This support consists of a timber cribbing in the center, then 4 by 4 posts in concentric rings out to the circumference. The first course is then riveted in place, the bottom tested with water, painted and lowered to its foundation. The lowering is done progressively from the center and the foundation

sprayed with road oil, applied hot, in advance of the lowering. The foundation was carefully smoothed by hand after the removal of the supporting posts and ahead of the oiling.

The erection of the sides was begun as soon as the bottom was firmly seated on the foundation. The plates were hauled from the stock pile to the tanks by a 10 ton Cletrack, and hoisted into place by a tractor crane with a 48 foot boom.

The riveting staging was carried on brackets of angle iron supported from holes drilled in the middle of each plate. After erection these holes are plugged and the plugs electric welded in place.

One sheet was left out of the bottom course to afford easy access to the interior until the erection was complete. The roof columns were taken inside through this door and hoisted into place by means of a traveling wooden tower equipped with an air hoist. The purlins were placed from the outside by the tractor crane.

The interior of the tanks is painted with Biturene enamel. This is applied in two coats, a primer coat applied cold, followed by a hot enamel coat. The bottoms of the tanks were coated with the same material before lowering to the oiled foundations.

The outside of the tanks was painted with a priming coat of red lead and an outside coat of aluminum. All surfaces were thoroughly wire brushed before painting.

Many of the oil companies at their tank farms are now letting their tanks stand unpainted for about a year. The tanks are then cleaned and a red lead primer and aluminum outer coat applied. In this way, all the mill scale is removed before painting.

The tanks were designed in the Engineering Offices of J. B. Lippincott. The contract for the fabrication and erection of the tanks was awarded to the Western Pipe and Steel Company of Los Angeles. About 1770 tons of steel were used in the construction of the six tanks. The contract price, which included roofing and painting, amounted to $77.40 per ton. The total amount of the two contracts, excavation for foundation and construction of tanks, was $150,700, or $7,250 per million gallons storage.

(Presented before the California Section meeting, October 28, 1932.)

FILTER SAND MAINTENANCE

By Frank W. Herring

(*Engineering News-Record, New York, N. Y.*)

Many of the ills to which filter beds are subject are of purely local origin, for example, a large amount of iron or manganese in the water being filtered. Most lime softening plants find that the sand grains increase in size by accumulating a deposit of calcium carbonate. But even when local conditions are eliminated in the ordinary rapid filter plant, using alum coagulation with a fairly turbid water, the filter bed develops certain types of disabilities that are widespread in occurrence. The most frequently encountered troubles of this nature are the formation of mud balls, cracking of the filter surface, and shrinkage away from the side wall. Many times two or three of these elements occur together and in all cases the condition is likely to become progressively worse as time goes on until the filter bed must be reconditioned. Reconditioning means usually the removal of the sand and its cleaning by some mechanical device, a costly and time-consuming procedure.

All rapid filter plants are provided with a washing system designed to keep the sand reasonably free from accumulations of foreign matter. But until recently it has been considered desirable to encourage the accumulation of coating on the sand grains in the belief that filtration efficiency would thereby be improved. The filter bed troubles that have been described almost invariably occur in these so-called well-seasoned filter beds. The cause is the accumulation of foreign matter on the sand far beyond the point where it might possibly be of value in filtration. Each sand grain accumulates a coating of aluminum floc combined with the material suspended in the water, a gelatinous coating, cohesive and easily compressed. It is this accumulation of dirt that encourages the formulation of mud balls, surface cracks and wall shrinkage.

The real preventative for these maladies is the maintenance of the sand in a clean condition. When the sand is removed from a filter for cleaning and then put back the troubles disappear for a time.

But after some months of service the same old ills usually recur. In other words, the sand grains re-accumulate sufficient material to put them again into the condition they were in before they were cleaned.

The wash-water facilities of the ordinary filter plant are not sufficient to remove from the sand the foreign matter that has accumulated over a long period of time. If sufficiently intense, however, the washing can prevent its further accumulation. The question then arises as to the necessary intensity to accomplish this result.

You are no doubt all familiar with the frequency of occurrence of these troubles in summer and their infrequency in winter. This is due to the more efficient washing obtained with cold water. Water is a viscous fluid just like oil or molasses and when cold it is relatively thicker and exerts more force upon the sand grains during the washing process. This means that if we desire to obtain the same efficiency in washing in summer as we do in winter, it would be necessary for us to increase the rate of application of wash water. On the other hand, if we have found a rate that is sufficient to keep the sand clean in summer time we may safely reduce it in winter.

The temperature of the water is only one of the items entering into a determination of the proper washing rate. The other factor is the size of the sand. A fine sand can be washed more easily than a coarse one. But the size of the sand with which the filter is provided is largely a matter of design and not one over which the operator can exercise much control. His problem is the utilization of the means at his disposal to obtain the best possible results.

Investigations have shown that the amount the bed is lifted, or expanded or swelled, during the wash is a satisfactory index of the washing intensity. The washing intensity, furthermore, will be sufficient to prevent the accumulation of coating if the resulting expansion is 50 percent or more of the original sand depth. That means that a 30 inch bed of sand should be swelled to a total depth of at least 45 inches while the washing is in progress.

If some means is used to measure the expansion during the washing process and the wash-water valve adjusted in each case to obtain the desired expansion, the operator will find that he is opening the valve wider in the summer time than in winter. This is because of the effect mentioned before of the relative thinness of the warmer water. Or, a few tests made at different seasons of the year will enable him to mark the position of the wash-water valve indicator that will give the proper rate of flow for various temperatures.

For satisfactory results, however, it is necessary to have the sand comparatively clean to start with. Otherwise, the expansion will be misleading because of the buoyancy of the gelatineous coating. This coating, when immersed, is extremely light and has the effect of reducing very materially the specific gravity of the sand grain. In fact, it is possible to tell how much coating there is by measuring the sand's specific gravity.

Relatively intense washing has now been practiced in the Detroit filter plant for about three years. Unfortunately, the sand is of such a size and the wash-water capacity has such a limit that it is impossible to get a 50 percent expansion in the summer months even when the wash-water valve is wide open. The best that can be done is to use all the capacity available. During the year the average rate of expansion obtained is only about 35 percent. But even so, the results obtained show a great improvement over the conditions during the time that the filters were washed at a rate of 24 inches per minute all year round.

Just before starting this new régime of washing, the sand was cleaned to the point where its specific gravity was 2.613. It is well at this point to remember that the specific gravity of clean silica sand is 2.650 and that specific gravity decreases as coating accumulates. During the three years of operation, the average specific gravity of the sand has dropped to 2.597. Interpreting this rate of decrease in specific gravity as the rate of accumulation of coating, the coating has accumulated only half as fast as it did during the earlier years of the plant's history. The sand in the filters now looks as clean as it did immediately after its reconditioning three years ago, but the figures show that it has recoated slightly.

However, there are three filters in the plant containing finer sand than the rest and in these filters the wash rate available is sufficient to produce a 50 percent expansion. The sand in those filters has not accumulated any coating at all in that time.

The operators of the plants at Mt. Clemens, and at Grosse Pointe, Mich., have been washing their filters on this basis ever since operation was begun. Mt. Clemens has been operating for two years with a 55 percent expansion. The specific gravity of the sand during that time, on a wet basis, has declined to 2.50. The amount of moisture retained by the sand, also an index of the accumulated coating, is only 4½ percent.

The Grosse Pointe sand has been in use for 10 months during which

it has been washed at a 45 percent expansion. The accumulated coating is so slight that it retains moisture equivalent to only 3 percent of the weight of the sand and the specific gravity of the sand, wet, is 2.55.

In the Detroit plant, the usual filter troubles are no longer in evidence to any appreciable extent. In the Mt. Clemens and Grosse Pointe plants the usual filter ailments have not appeared at all.

(*Presented before the Indiana Section meeting, March 10, 1932.*)

B. COLI IN COLD BLOODED ANIMALS

By J. Wendell Burger and Stanley Thomas

(*Laboratory of Bacteriology, Lehigh University, Bethlehem, Pa.*)

That members of the colon-aerogenes group occur in cold blooded animals is well known. Prescott and Winslow[1] have summarized much of the work thereon, indicating that the organism is not as regularly found in cold blooded as in the warm blooded animals. Kline and Nelson[2] found the intestines of salamanders act as incubators for B. coli, and that the organism may persist in the intestines for considerable time. One of these animals threw off 36,000 B. coli per day.

This work records 80 individual animals: 21 reptiles (12 species) and 59 amphibia (9 species). It may add to a not too full literature on the subject, and to the persistence of the organism in forms other than salamanders.

In early July, 1932, it was noticed that a small (800,000 gallon) concrete storage reservoir at Easton, Pa., was victimized by newly metamorphized frogs, Rana pipiens. A conservative estimate of the number was 2000. This reservoir was situated on the top of a small mountain, and not subject to the catchment of drainage. The frogs spent their life from the egg to the adult in this water, and due to the reservoir water level did not get off the concrete slope of the reservoir. Moreover, this water received the chloramine treatment, with analyses showing it to be a safe water for public consumption. Eleven of these frogs were dissected (see below for procedure), and contents of intestines put in lactose broth, and then on E.M.B. Analysis of the reservoir water was made at the same time. All individuals yielded organisms showing acid and gas in lactose, and characteristic coli colonies on E.M.B. The reservoir water was negative.

A few days later three more frogs from the same source were dissected. From one of these specimens were taken several parts of the

[1] Prescott, S. C., and Winslow, C.-E. A.: Elements of Water Bacteriology, pp. 93–95. Wiley & Sons, 1931.

[2] Kline, E. K., and Nelson, F. M.: American Journal of Public Health, July, 1932, pp. 691–9.

alimentary tract including the lower intestine, upper intestine, gall bladder, and stomach. The result was the same as in the first case. Coli were found everywhere in the tract, but the stomach. At this time, the characteristic E.M.B. colonies were fished, and inoculated into coli-aerogenes differential media. All three frogs showed typical B. coli and one intermediate organism common to them all.

Needless to say, the reservoirs were immediately cleaned, and the frogs removed. The fact that the reservoir was B. coli free points to the efficacy of the chloramine treatment.

Due to the finding of coli in every one of 14 frogs, it was decided to extend the series. Preliminary evidence indicated that frogs could be carriers of B. coli even though their chances of engulfing B. coli from treated water were not constant or highly favorable from a numerical point of view. It was judged the early spring months, March to May, would be the most favorable time, since during this period temperatures would be low (the cold blooded animal's body temperature being only a little higher than the environment); animals would be just emerging from hibernation and easier to catch than during the winter; and with rains, lack of animals in pasture, etc., the small streams would not be as highly contaminated as during the summer.

The procedure was of two sorts: (1) Animals that it was not desirable to kill were made to excrete into 5 cc. of sterile distilled water in a petri dish. A firm massage of the abdomen will accomplish this. The animal is held firmly above the dish so it can not contaminate the water with its body, or by writhings. (2) Other animals were killed by decapitation and pinned to a phenol soaked board, after a careful washing with coli free tap water, and then sterile distilled water. At first the animals were swabbed with 5 percent phenol, but tests indicated this was unnecessary. The belly was opened, the intestine removed, and chopped with sterile water in a perti dish. Sterile instruments were used.

Inoculations were made to lactose broth. Only acid and gas tubes were read positively. Plates were made on E.M.B. and characteristic coli colonies differentiated according to standard methods. No attention was paid to anaerobes, save to show they existed; nor were coli-like organisms differentiated specifically. Wherever possible, the water wherein the animals lived was analyzed according to Standard Methods.

The results appear in tables 1 and 2 and show that colon-aerogenes organisms are found more frequently in reptiles than in amphibia.

TABLE 1

Reptilia

	LACTOSE	E.M.B.	INDOLE	METHYL RED	VOGES PROSKAUER	KOSER'S CITRATE
I. 3/28, Chrysemys picta (Painted turtle) intestines entirely empty:						
a. cloaca	AG	+	+	+	−	+
b. lower intestine	AG	+	+	+	−	+
c. mid intestine	AG	+	+	+	−	+
d. upper intestine	AG	+	+	+	−	+
e. gall bladder	−					
f. stomach	−					
Habitat	AG in 4 of 5	+				
II. 3/28, Lampropeltis getulus holbrooki (King snake), eaten a number of snakes	AG	+	+	+	−	+
III. 3/28, Heterodon contortrix (puff adder), hadn't eaten in 2 months.	AG	−				
IV. 3/28, Crotalus horridus (timber rattler), eaten mice	AG	−				
V. 3/28, Anolis carolinensis (chameleon)	−					
VI. 4/24, Sceloporus undulatus (pine lizard)	AG	−				
VI. Sceloporus undulatus (pine lizard)	AG	+	−	−	+	+
VII. 4/26, Elaphe obsoleta (blue racer) just emerged from hibernation	AG	+	+	+	−	+
		+	−	−	−	+
VII. 4/26, Coluber constrictor (black snake) just emerged from hibernation	AG	+	+	+	+	−
ditto	AG	+	+	−	−	+
ditto	AG	+	+	+	−	+
		+	+	+	+	−
ditto	AG	+	+	+	−	+
ditto	AG	+	+	+	−	+
		+	+	+	+	−
ditto	−					
ditto	AG	+	+	+	−	+
		+	+	+	+	−
ditto	AG	+	+	+	−	+
		+	+	+	+	−

TABLE 1—*Concluded*

	LACTOSE	E.M.B.	INDOLE	METHYL RED	VOGES PROSKAUER	KOSER'S CITRATE
VII. 4/26, Coluber constrictor (black snake) just emerged from hibernation	AG	+	+	+	−	+
		+	+	+	+	−
ditto	AG	+	+	+	−	+
		+	+	+	+	−
VIII. 5/2, Thamnophis sauritus (ribbon snake)	AG	+	+	+	−	−
I. 5/2, Chlemmys guttata (spotted turtle):						
a. lower intestine	AG	+	+	+	−	−
b. upper intestine	AG	+	+	+	−	−
I. 5/3, Kinosternum oderatum (stink pot):						
a. lower intestine	AG	+	+	+	−	+
b. upper intestine	AG	+	+	+	−	+
Habitat	AG to $\frac{1}{10}$	+	aerogenes colonies			

Symbols: Roman numerals and capital letters indicate habitats. 5/3 example of date of collection. AG—acid and gas.

It would be foolish with so small a series of animals, and with no statistical correction for the number from one source, to say on this evidence any difference existed in these two groups.

It is clear, however, that B. coli is able to persist in these animals. The series of black snakes were found just emerging from hibernation, with dirt still on their bodies. It is almost certain they had not wandered to streams or ponds to drink, nor had they eaten. Yet colon-aerogenes were found in 10 out of 11 of them. Also three salamanders (Pseudotriton ruber) showed coli, while the control was negative. In the case of organisms (H, I, J), the organisms from the intestine differed from those found in their habitat, the former being coli-like colonies, the latter aerogenes. It should be added that while B. coli itself was not found very often, the E.M.B. colonies were what one would call coli rather than aerogenes types. The difference from typical B. coli was the ability to utilize Koser's citrate. Controls indicate this is not due to the quality of the media. On the other hand, the series gave B. coli in only one animal, where the water was B. coli free.

TABLE 2

Amphibia

	LACTOSE	E.M.B.	INDOLE	METHYL RED	VOGES PROS-KAUER	KOSER'S CITRATE
A. 6/32, Rana pipiens	AG	+		Not done		
ditto	AG	+		“		
ditto	AG	+		“		
ditto	AG	+		“		
ditto	AG	+		“		
ditto	AG	+		“		
ditto	AG	+		“		
ditto	AG	+		“		
ditto	AG	+		“		
ditto	AG	+		“		
ditto	AG	+		“		
ditto	AG	+	+	+	–	–
		+	–	+	–	+
ditto	AG	+	+	+	–	–
		+	–	+	–	+
ditto, lower intestine	AG	+	+	+	–	–
		+	–	+	–	+
mid intestine	AG	+	–	+	–	+
upper intestine	AG	+	+	+	–	–
gall bladder	AG	+	+	+	–	–
stomach	–					
Habitat (reservoir)	–					
B. 3/28, Rana sylvatica (wood frog) adult	–					
ditto	AG	+	–	+	–	+
ditto	–					
ditto	–					
Habitat	4 of 5 AG	+				
C. 3/28, Rana clamitans, tadpoles (green frog)	AG	–				
ditto	AG	–				
ditto	AG	–				
ditto	AG	–				
ditto	AG	+	+	+	–	–
ditto	AG	–				
C. 3/28, Rana pipiens, tadpoles (leopard frog)	–					
ditto	–					
C. 3/28, Triturus viridescens (newt)	AG	–				
ditto	–					

TABLE 2—*Continued*

	LACTOSE	E.M.B.	INDOLE	METHYL RED	VOGES PROS-KAUER	KOSER'S CITRATE
C. 3/28, Triturus viridescens (newt)	–					
ditto	–					
ditto	–					
ditto	–					
ditto	–					
ditto	–					
Habitat	–					
D. 5/28, Eurycea bislineata (2 lined salamander)	AG	–				
ditto	–					
D. 3/28, Desmognathus fuscus	–					
ditto	AG					
ditto	AG	–				
ditto	–					
D. 3/28, Pseudotriton ruber (red salamander)	–					
Habitat	–					
E. 3/30, Hyla crucifer (spring peeper)	AG					
ditto	AG	+	+	+	–	+
ditto	AG	+	+	+	–	+
Habitat (ditch)	AG thru 1 cc.	+				
F. 4/25, Pseudotriton ruber	AG	+	–	+	–	+
ditto	AG	+	–	+	–	+
ditto	AG	+	–	+	–	+
Habitat	–					
G. 4/25, Plethodon glutinosus (slimy salamander)	AG	–				
H. 5/2, Rana palustris (pickeral frog):						
lower intestine	AG	+	+	+	–	+
upper intesting	–					
H. Rana clamitans (green frog)	AG	–				
ditto	AG	+	+	+	–	+
ditto	AG	+	+	+	–	+
Habitat, (stream)	AG thru $\frac{1}{10}$	+	aerogenes type			
I. Rana clamitans	–					
Habitat	AG thru 1 cc.	+	aerogenes			
J. 5/2, Rana clamitans, tadpole	AG	+	+	+	–	+

TABLE 2—*Concluded*

	LACTOSE	E.M.B.	INDOLE	METHYL RED	VOGES PROSKAUER	KOSER'S CITRATE
J. 5/2, Rana clamitans, tadpole	AG	+	+	+	−	−
ditto	AG	+	+	+	−	−
ditto	AG	+	+	+	−	−
ditto	AG	+	+	+	−	−
Habitat (stream)	AG thru 1 cc.	+	aerogenes			
K. 5/12 Rana clamitans	AG	+				
Habitat (stream)	AG thru 10 cc.					

It is noticed tadpoles as well as adults may have B. coli. Since tadpoles are often present in large numbers, and since they are very active feeders with extremely long intestines, they may be of some sanitary importance. B. coli, as Kline and Fuller found, is distributed throughout the alimentary tract below the pylorus. This condition was found in one turtle where the intestines were entirely devoid of food. The single record of occurrence in the gall bladder is no doubt due to seepage through peritoneal fluid from the cut end of an intestine. One failure was made in getting coli from the upper intestine, when present in the lower. But it is quite evident that cold blooded animals can be easily infected, and thereupon exhibit some independence from their habitat. Culturally most of the organisms found are of B. coli characteristics.

In dealing with the organisms from (C), a lactose fermenting spore former was encountered, which gave very small colonies simulating B. coli, and which, if the colonies were not well separated, might be misjudged as due to overcrowding of coli colonies. Other false presumptives were not infrequent.

PUBLIC HEALTH ENGINEERING IN QUEBEC

By T. J. Lafrenière

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Public health has been defined as the science and the art of preventing disease, prolonging life and promoting physical health and efficiency through organized community efforts. Modern public health had its origin in England, in the middle of the 19th century, where sanitary conditions had become unbearable in the urban centers created by the development of industries.

Public health first concerned itself with the improvement of the environment and it was then really an art, as the biologist and the chemist had not given to the world the scientific principles upon which public health is now based. Municipal sanitation was the important part of any public health program. Although the germ theory of disease had not been established, it was recognized that abundance of water was necessary to promote health in cities and towns; it was also known that the spent water needed to be carried away in order to prevent intolerable conditions.

With the advent of the bacteriologist, in the latter part of the century, preventive medicine became an essential feature of environmental sanitation. Today, the physiologist has given a new impetus to the movement of health conservation, and personal hygiene, applied collectively, forms part of a well rounded public health program.

Public health in the province of Quebec dates back to 1676 when a law was passed ordering every householder to have a privy pit and to take necessary measures to prevent nuisances. In 1706, the inspection of bread and meat was established and, in the same year, the Chief of Police of the colony, visiting Montreal, found the streets in such a deplorable state that he ordered their reconstruction and required sewers on St. Pierre Street.

After the cession of Canada to England, in 1763, health matters remained stationary but the measures edicted under the French régime were maintained. From that date, the Government concerned itself with public health at times of epidemics only, but, in 1870, the Munic-

ipal Code was passed, giving to every municipality the powers to make regulations concerning health matters such as inspection of buildings, abatement of nuisances, construction of water and sewerage systems and control of infectious diseases. Few municipalities used the powers granted by this Act and when the small-pox epidemic occurred in 1885, the Legislative authorities passed a special Act creating a Commission which later became the permanent Board of Health of the province.

At first, the organization of the Board of Health consisted of a President, a Secretary, and one Inspector, but in 1893, a Statistician, a Chemist and a Bacteriologist were appointed; in 1899, Consulting Sanitary Engineers were nominated, until 1909 when a division of Sanitary Engineering was created. In 1911, the province was divided into 10 districts with a medical Inspector in charge of each district; later, this was increased to 20 districts. In 1926, County Health Units were created and the system proved so successful that in 1933, 28 County units, serving 35 counties in the province, were in operation.

Public health engineering in Quebec, which developed especially after the creation of a sanitary engineering division, is concerned with the improvement of the environment, thus promoting health and comfort. Its various activities can be enumerated as follows: Water supply, Sewerage, Milk supply, Housing and Nuisances. The Public Health Act has been amended repeatedly to meet new conditions and to provide for further health development.

WATER SUPPLY

Surveys of waterworks in the province of Quebec have been made at different times and the last one is now being completed. The reports now in hand, covering the larger part of the province, are shown in table 1.

Rivers are used as a source of supply by the larger municipalities. The numerous lakes in the province are not within economical distances as the towns have developed mostly on the shores of rivers. The group using underground waters is composed largely of small municipalities; the geology of the province does not favor underground supplies.

The general use of the rivers as a source of supply has caused numerous typhoid fever epidemics and it has been the main concern of the Sanitary Engineering Division to obtain the improvement of these

supplies. Filtration plants were established in the larger cities and towns, and chlorination plants were installed in those municipalities that could not for the present afford the cost of filter works or where the supply did not require filtration.

TABLE 1

Water works in Quebec

NUMBER	POPULATION (1931)	SOURCE OF SUPPLY
204	1,526,300	Rivers
71	106,800	Lakes
331	190,000	Springs and wells
606	1,823,100	

TABLE 2

Water purification

TYPE	NUMBER OF INSTALLATIONS	NUMBER OF MUNICIPALITIES SERVED	POPULATION (1931)
Filtration	47	66	1,205,700
Chlorination	31	38	284,800
Total	78	104	1,490,500

Source of treated waters

SOURCE OF SUPPLY	NUMBER OF MUNICIPALITIES SERVED	POPULATION (1931)
Rivers	91	1,447,300
Lakes	9	38,200
Springs and wells	4	5,000
Total	104	1,490,500

TABLE 3

Decrease in typhoid death rate

(Figures in deaths per 100,000)

1910-14	1915-19	1920-24	1925-29	1930	1931	1932
25.5	22.2	15.5	10.2*	9.1	7.7	6.8

* Exclusive of Montreal milk epidemic in 1927.

The operation of these treatment works under the supervision of the Sanitary Engineering Division of the Bureau of Health, had a marked effect on the typhoid death rate of the province.

The rate of 1932 is the lowest ever attained in the province, although it is high when compared with other provinces in Canada. However, the character of the province should be here considered. Quebec is still a rural province; its population of 2,875,000 inhabitants, according to the 1931 census, is distributed as shown in table 4.

All the cities of the province are provided with a safe water supply and 95 percent of towns also have satisfactory waters. The villages have not as good a record, but underground waters are largely used in these centres. We still have in the province a population of approximately 80,000 inhabitants, divided among 113 municipalities, supplied with surface waters without treatment. Happily enough, a good many of the streams used are not exposed to human contamination. The water supply problem of the province is not completely solved. Water treatment is required in a few municipalities, but the present economic conditions have forced the municipal corporations to delay the necessary improvements.

TABLE 4

Distribution of population according to municipal organization

TYPE	NUMBER	POPULATION OF GROUP
Cities	25	1,329,600
Towns	97	239,600
Villages	298	240,100
Rural municipalities	1010	1,065,700
Total	1430	2,875,000

SEWERAGE

Waterworks in the urban centres are completed by the construction of sewerage systems. A total population of 1,650,000 in 362 towns is served by public sewers. The sewage is generally discharged into the river without previous treatment as the flow of our streams is large and affords the necessary facilities for dilution. Sewage treatment has been required in a few exceptional cases to prevent local nuisances or to protect nearby water-supplies. The method consists in sedimentation followed by chlorination.

However, the Quebec Public Health Act provides for the construction of either water or sewerage systems in common for contiguous municipalities and this power has been used in numerous cases either to prohibit the installation of an undesirable water intake or to prevent the contamination of a stretch of river used for water-supply purposes.

MILK PASTEURIZATION

The milk supply of the province was controlled through general clauses of the Public Health Act, until 1927, when a special section was added to the Act, entrusting to the Board the control of milk pasteurization plants in the province, similarly as it controls water purification works. In 1932, there were in the province 88 milk pasteurization plants supplying 85,000 gallons of milk daily to a population of 1,370,000 people. Eight plants have been closed since the beginning of the year. The pasteurization of milk is compulsory in the City of Montreal and vicinity only, although there are 43 plants in the province, outside what is designated as "Greater Montreal." Approximately 45 percent of the population is served with pasteurized milk and we feel that the generalization of milk pasteurization has helped in reducing our typhoid death rate. The milk consumption in the province, based on the pasteurized milk figures, is one-third of a quart per head, per day.

HOUSING

General By-Laws limiting the height of buildings, the width of the streets, as also the percentage of the lot which can be occupied by dwellings, control the housing problem in the province. However, these by-laws are applied by the municipal authorities, except in the County Health Units where the Medical Officer is substituted to the local authorities. The housing problem is one of the cities and the municipal corporations in such centres have adequate organizations. There is no special Town-Planning Act in the province, but the cities and Town's Act, as also the Municipal Code, give to the municipalities the necesary powers to control their development.

NUISANCES

The Sanitary Engineering division of the Board is consulted in the matter of nuisances when the district Inspector or the County Health

Officer deems fit to do so. His action is more of a consulting capacity than otherwise.

Problems in refuse collection and disposal are assimilated to nuisances. The larger cities have systematic collection of refuse and incinerators of the destruction type are used. However, in the smaller towns, the refuse is disposed of by dumping, usually in abandoned quarries, or the individual is left to his own means to get rid of his rubbish.

The control of water and milk supplies, sewerage, housing and nuisances, constitute the main activities of the Engineering Division of the Bureau of Health of the province of Quebec. The examination and control of swimming-pools is carried from the point of view of education; bathing-beaches are becoming a problem which will require special treatment; the tourist camps are under the jurisdiction of a special department concerned with the supervision of hotels; the ventilation of schools and public buildings is controlled by general by-laws in which natural ventilation is accepted on a par with mechanical means of circulating the air. Cross-connections between public and industrial water-supplies have been prevented in recent years but amendments to the Public Health Act are now before the Legislature which, it is hoped, will permit to improve the existing ones which constitute a public danger

In conclusion, the Quebec Public Health Act contains the necessary powers to control the environment for the benefit of the public. Preventive medicine has progressed in the province with the help of the biologist and the physiologist. The public health engineer is still necessary to maintain the sanitary conditions obtained through past efforts and to apply the new discoveries for the greater benefit of the public.

(Presented before the Canadian Section meeting, March 24, 1933.)

AMMONIA-CHLORINE TREATMENT AT CHAMPAIGN-URBANA, ILLINOIS

By Frank C. Amsbary, Jr.

(Superintendent, Illinois Water Service Company, Champaign, Ill.)

A brief summary of the troubles at Champaign and Urbana will be helpful in giving a clear picture of conditions leading up to the decision of trying the ammonia-chlorine treatment.

Most of you are well acquainted, through previous papers, with the iron bacteria growths in the distribution system. To combat this growth an experimental iron removal plant was erected by Professor A. N. Talbot in 1910 and 11 and the building of the first units of the filtration plant in 1912.

Conditions in the distribution system were so much better after the filter plant was placed in operation that the growth troubles were relatively over.

It was not until 1918 that the iron removal problems had been overcome to the point of satisfactory filter operation. The turning point for the good came with the introduction of pre-chlorination. The difficulties leading up to the application of chlorine in the filter influent was the luxuriant iorn bacteria growths in the filter beds which prevented any flow through the sand beds. Chlorine controlled this growth so that regular dependable filter operation was assured.

This treatment has been continued to date and with an average of about 20 pounds per million gallons of water, the sand beds have been kept in almost perfect condition.

Iron bacteria have not presented the only case for solution, but have been the most persistent and difficult to deal with.

At one time more complaints were received as the result of the larvae commonly known as the "blood worm." This trouble was entirely eliminated after the clear wells were covered with concrete roofs. These roofs prevented the gnats from laying their eggs in the water which later turned into the worms.

The amount of free ammonia found in the water as it comes from

the wells is of interest. Tests show this to be 5.4 p.p.m. This high content of ammonia undoubtedly stimulates the luxuriant growths of bacteria found in the distribution system.

No doubt many of you will remember the day when ammonia in this quantity found in a supply would have been looked at with askance.

Never had the growth of iron bacteria been entirely eliminated from the distribution system. Complaints were few, however, and an occasional flush at various points kept the water in a very acceptable condition until 1931.

The organisms definitely identified in this system are Crenothrix and Spirophyllum. There is also a white, grayish gelatinous flocculent growth which under the microscope shows the presence of organisms similar in form to iron bacteria.

In 1931 the filter efficiency dropped to a new low, and by the time they had been renovated and replaced into service the iron bacteria troubles had increased many fold and some drastic change in treatment had to be made to clear the distribution system of these growths as rapidly and effectively as possible.

Ammonia-chlorine was decided upon. Because of its experimental nature, it was decided not to purchase an ammoniator until it had been determined that this treatment would be a definite aid in the plant operation.

In July, 1931, the ammonia-chlorine treatment was started. An ammonia solution was made in a barrel and fed by gravity into the filter effluent through an orifice over which a constant head was maintained with a float valve, thereby getting a constant flow of the solution.

The original dosage was 0.6 p.p.m. of chloramine in the clear well with the proportion of ammonia one to two of chlorine.

This treatment was continued for two weeks. At the end of that time, due to a continuance of growths in the clear well, the dosage was doubled, which boosted it to 1.2 p.p.m. in the clear well.

Inasmuch as there was a decided taste the ammonia was increased to 1½ to 2 parts of chlorine. This helped the situation, but the taste was still noticeable.

It is peculiar to note that a complaint will be entered more quickly because of a few threads of iron bacteria rather than from a strong taste.

This is probably due to the fact, so the psychologist says, that 80 percent of the human's reactions are due to the sight.

During this period satisfactory residuals were found throughout the entire distribution system after continuous night flushing. But as soon as the night flushing was stopped the residual disappeared with continued trouble from growths.

Even with the residual of 1.2 p.p.m. in the clear well the growths persisted there. Feeling that possibly the filter beds were thoroughly saturated with these growths and that they were constantly being fed into the clear well, it was decided to try a chloramine treatment in the influent and thoroughly sterilize the sand beds.

Before this time chlorine residuals as high as 1 part had been carried in the influent with no residuals showing up in the affluent.

The chloramine influent treatment was started on August 8, 1931, carrying 0.9 p.p.m. In 18 hours a residual showed up in the effluent of some filters. The maximum was 0.33 and the minimum 0 p.p.m. By August 19, after eleven days of the chloramine influent treatment, these residuals had increased to a maximum of 0.5 and a minimum of 0.08 p.p.m.

This treatment was continued until the clear well was free from growths, about four months. During this period the dose had slowly been increased to 1.2 p.p.m. with some filters showing as high as 0.9 p.p.m. in the effluent.

Continuing with a heavy influent dose of chlorine the application of ammonia was moved back to the effluent.

So much for the preliminary steps in the treatment. The necessary information has been gained to point out a definite program for treatment.

First, satisfactory residuals could be had in the distribution system by treating at the rate of about 1 part chloramine in the clear well and by continuing night flushing.

Second, results showed the filter beds to be fairly free from these growths, with iron removal improving to an average of 0.0022 p.p.m. in the effluent.

Third, because of the heavy chlorine loss through the filter beds, the only economic point of application for the treatment of the distribution system was in the filter effluent.

The accepted method for combining ammonia in chlorine is to apply the ammonia first, after complete mixing, then the chlorine, the theory being to prevent the chlorophenol taste. Phenols not being present in this water, the regular procedure in dosing with ammonia-chlorine was disregarded.

After the chloramine treatment was discontinued in the influent the chlorine residual continued to show up in the effluent. Remember the pre-chlorination was continued, only the application of ammonia in the influent was stopped.

With a small chlorine residual in the filter effluent, dosing with ammonia, then the second application of chlorine, what would be the results? Would the ammonia combine completely with the small residual from the filter effluent making a weak chloramine, and the second application be present as free chlorine? If so, our ammonia treatment would be a waste of time and money.

Because of this possibility, having no phenols to worry about, and with time an important factor, it was decided to ignore precedent and reverse the points of application of the chlorine and ammonia.

This procedure has not been changed to date and seems to have been satisfactory in every detail.

RESULTS IN DISTRIBUTION SYSTEM

This paper has so far been concerned entirely with the method of treatment. The results are interesting, but first a brief description of the conditions throughout the distribution system before the treatment was started is necessary to give a comprehensive picture of the situation.

Flushing anywhere showed an abundance of iron bacteria growths. The streets were literally brown with them after flushing. Flushes of reasonable length would in some cases result in a clear water. In other cases after flushing for 45 minutes, through a 5-inch outlet and the hydrant wide open, the water would not clear up satisfactorily.

In the case of isolated small lines, 2-inch and smaller, the ends were dug up and blow-offs the full diameter of the lines were installed. Some of these lines were so badly infected with the growth that upon opening the blow-offs wide the iron bacteria would come out like corn syrup, part in a decomposed state.

To follow the progress of the penetration of chloramine in the distribution system, representative points throughout the two towns were picked out and all tests have been made with regularity at these points.

A volume would be necessary to give all of these tests, so only a few will be given here to show that progress has been made. This progress has been slow, but steadily encouraging. In fact, one of the most interesting points of this treatment has been the slowness of its

progress. The apparent capacity of these growths to absorb the chloramine, and their resistance to it is most unbelievable.

Today it is thought that the situation is well in hand. Iron bacteria showing up at a flush is the unusual rather than the usual and then it is in such small quantities that diligent searching is necessary to locate it.

The progress of the treatments is shown in table 1. These tests are self explanatory. You will note that the dosage at the start was high with no residuals in the distribution system until after thorough flushing.

After the elevated storage tank in West Champaign was installed no flushing was done in this district. The filling of the tank at night

TABLE 1

Progress of chloramine treatments as shown by residual chlorines (in p.p.m.)

DATE	DOSE AT PLANT	CHAMPAIGN DOWN TOWN	CHAMPAIGN W. RESIDENTIAL	CHAMPAIGN NORTHWEST	CHAMPAIGN SOUTHWEST	URBANA DOWN TOWN	URBANA SOUTHEAST	REMARKS
7/ 5/31	1.20	0.15	0.00	0.00	Trace	0.05	0.00	First tests
7/30/31	1.20	0.95	0.70	0.70	0.60	0.05	0.00	Flushing
12/18/32	0.67	0.70	0.35	0.04	0.10	0.65	0.05	
4/ 1/33	0.60	0.60	0.25	0.04	0.10	0.55	0.02	
4/18/33	0.55	0.55	0.20	0.15	0.15	0.50	0.15	Flushing
4/22/33	0.60	0.55	0.40	0.15	0.30	0.50	0.05	

caused more water to move through the distribution system in this general direction than flushing could possibly do.

With this hypothesis you will note that with tapering down the plant dosage the residuals in the distribution system have shown a gain. Southeast Urbana will be thoroughly flushed this spring with a heavy treatment at the plant during that period. The fact that the complaints of iron bacteria have been entirely, with few exceptions, in the western end of the distribution system, the eastern section has been more or less disregarded up until now.

From April 14 to 17, 1933, the elevated storage tank was emptied and thoroughly cleaned. The treatment at the plant was increased to 1.2 p.p.m. and after very thorough flushing the tank was refilled.

The last tests shown on table 1 clearly show the results of this program.

This work has been carried out under the general supervision of Mr.

P. L. McLaughlin, Chief Sanitary Engineer of the Illinois Water Service Company.

The writer is greatly indebted to Mr. T. R. Dyer, filter operator at the Champaign-Urbana plant for the exacting manner in which he has executed the mechanics of the treatment, his timely suggestions and the almost inexhaustible amount of data which he has accurately kept for reference.

Dr. A. M. Buswell, of the Illinois State Water Survey made several suggestions in the writing of this paper, for which appreciation is here expressed.

(*Presented before the Illinois Section meeting, April 20, 1933.*)

AMMONIA-CHLORINE TREATMENT IN DANVILLE, ILLINOIS

By Howard M. Ely
(*Superintendent, Interstate Water Company, Danville, Ill.*)

Water at the Danville plant is pumped by centrifugal pumps either through an aerator or by-passed around it, as required, to the mixing chamber, which is 75 feet in length by 6 feet in width by 20 feet deep and contains over and under baffles. From this chamber, the water flows by gravity into a rectangular shaped settling basin, 270 feet long, 130 feet wide and 20 feet deep, having one around-the-end baffle wall through the center. From this basin, the flow is by gravity to rapid sand filters, to the clear well and to the high service pump suction well.

Ammonia is introduced into the suction of the raw water centrifugal pump and the chlorine into the discharge pipe ten feet beyond the pump. The water thus charged travels through the 18 inch discharge pipe about 100 feet to the settling basin, requiring about 18 minutes for passage. The retention period in the settling basin is about 10.5 hours at 4.5 m.g.d. rate. After leaving the filters, there is a period of about 3 hours before the water reaches the first consumer in the distribution system.

We had already installed vacuum type chlorinator in duplicate units, discharging into the filter effluent and about the middle of January, 1932, we installed an ammoniator and began the ammonia-chlorine treatment. It was necessary, of course, at first to experiment with different amounts of ammonia and chlorine and with different ratios. Much greater amounts were used at first, because the filter beds took up all the chlorine and ammonia. The next day, after starting with a residual of 0.4 p.p.m. in the settling basin outlet, we found no residual in the transmission main leading from the Pumping Station, nor did we even find any in the filter controllers. The following day there was still none in some of the controllers and in others from 0.1 to 0.2 p.p.m., all the chlorine being taken up in the filter beds. It was then necessary to eliminate this loss of chlorine in the beds. The next day, therefore, the chlorine was introduced

directly into the filter influent pipe with a charge of 12 pounds per million gallons of chlorine. This gave us somewhat better results, but still unsatisfactory. After several days, the chlorine was introduced directly into the filter intake troughs with a charge of 12 pounds per million gallons of chlorine. The filter bed walls were wire-brushed and scrubbed down with H. T. H. This direct treatment of the filter beds was carried on for about three weeks, introducing the chlorine directly from the chlorinator into the filter beds one at a time and alternating the beds. By this time, we were able to maintain a residual of 0.2 and 0.3 p.p.m. in the controllers and a residual of at least 0.2 in the transmission main. We check up on the disinfection of the distribution system by occasionally taking samples from 25 to 30 fire hydrants throughout the system for residual chlorine test. For some time we obtained a residual of 0.1 p.p.m., but we are now able to maintain a rather uniform residual of 0.2 p.p.m. throughout the distribution system.

In using chlorine alone, in order to maintain a residual of 0.2 p.p.m. in the transmission main, it was necessary to use 11.6 pounds per million gallons or 1.45 p.p.m. at a cost of $0.875 per million gallons.

After experimenting with various amounts and ratios of ammonia and chlorine, we found that a ratio of one of ammonia to four of chlorine was most satisfactory. During the months of March to June inclusive, 1932, and from November and December of that year on through February and March, 1933, the average amount of ammonia has been 1.3 pounds per million gallons or 0.16 p.p.m., and 5.4 pounds of chlorine per million gallons or 0.65 p.p.m., at an average cost of $0.62 per million gallons, which is $0.25 per million less than with chlorine alone.

During the months of July, August, September and half of October, 1932, we experienced continuous algae conditions, which required the use of heavier ammonia, chlorine and alum dosages, together with much more frequent filter washings. The maximum amount of ammonia used during this period was 2.5 pounds per million gallons or 0.31 p.p.m. and 16 pounds of chlorine per million gallons. This 16 pounds, however, is divided between 10.6 pre-chlorination and 5.4 post-chlorination at a cost of $1.25 per million gallons, with a minimum of $0.96, average of $1.12. The cost of chlorine alone would have been still higher and we would not have eliminated the algae trouble. For the past three weeks we have reduced our ammonia-chlorine dosages from that of the former normal to 1.1 pounds ammonia and 4.4 pounds of chlorine at a cost of $0.51 per million gallons, which is

$0.11 cheaper than our former figure and $0.36 per million cheaper than the use of chlorine alone. With our average pumpage this cuts the cost from that of chlorine alone, at $3.83 per day, to $2.21 for the ammonia-chlorine or $1.62 less, but this saving is not the most important thing. The benefits to be derived, providing the cost is not excessive, is the thing to consider.

From the experience elsewhere, we did not expect very much in the way of taste and odor reduction from this treatment, although we have since noted that some plants report a partial algae control and many more a complete control. Our principal reasons for using it were for the prevention of aftergrowths, the continued disinfection throughout the distribution system, the prevention of chlorinous taste in the water, and the ability to use larger chlorine charges without taste. Chloro-phenol troubles we do not have to contend with. Early in the season, we stocked a trial quantity of Nuchar intending to use it in taste and odor prevention, if the ammonia-chlorine treatment failed in that respect. We did not have to use it, but some time we may get a different form of algae and may have a resort to activated carbon.

Algae were entirely eliminated from the filter beds and walls, and they have been kept perfectly free and clean ever since. Earlier in the summer, before we arrived at the proper dosages, there had been some growth of algae on the sloping sides of the settling basin at the water line and extending down a few feet. Later on much of this peeled off like a carpet unrolled, and there was very much less algae on the water surface than formerly, what there was, did not result in taste and odor, but did last for 3½ months and necessitated higher dosages and very frequent filter washings.

We do not now have the occasional comments on chlorine taste, or the more numerous and real complaints resulting from algae. On the contrary, consumers have frequently commented on the better quality of the water. This, together with the further protection afforded against water borne diseases, by sterilization throughout the distribution system, make the ammonia-chlorine treatment very much worth while, even if the cost exceeded that of chlorine alone, which it does not.

This treatment marks one of the greatest advancements in water supply control and is beneficial in all three of the ways mentioned above. It is not only a very desirable treatment, but is one which the water works official cannot afford to do without.

(Presented before the Illinois Section meeting, April 20, 1933.)

CHLORINATION IN THE PRESENCE OF TRACES OF AMMONIA

By Louis B. Harrison

(*Superintendent of Filtration, Bay City, Mich.*)

Water treatment at the Bay City plant consists in adding ammonia to the water at the suction well and after 15 minutes thorough mixing the ammoniated water reaches the head house where a pre-dose of chlorine is added, and then alum, lime or soda ash, depending on the condition of the raw water. The filtered water is quite often by-passed to the carbon beds for the removal of objectionable tastes. At the gate house a post dose of chlorine is added.

Several years of observation show that:

1. It is possible to produce in the finished product a chlorinous odor in spite of the fact that as little as 0.05 p.p.m. residual chlorine is left. This is true particularly during winter.
2. Samples for bacteriological examination have been collected twice daily, one sample at night was kept in the refrigerator until the next morning, and the second during the day. Invariably, in the case of poor bacteriological results the sample collected in the afternoon and tested immediately has shown the poorer results.
3. The poor bacteriological results would persist with the increase in the amount of residual chlorine.
4. The water in the city mains showed up much better bacteriologically than the treated water leaving the plant.
5. When the raw water is pre-chlorinated and the dose added is so regulated that the filter effluent is free of chlorine, as determined by the ortho-tolidin test, the ammonia is in no way used up and when another dose of chlorine is added, a substance which we call chloramine is formed again.
6. The chloramine does not cause the sterilization, but the liberated chlorine does. The chloramine gives up the chlorine slowly, depending on temperature conditions and, hence, reacts much more slowly than when free chlorine alone is used.
7. It is not the excess residual chlorine that is responsible for the bactericidal effect, but the contact period of the water with chlorine.

8. In order to get the best germicidal results it is important to know that sufficient chlorine is present in the water to last during a definitely established contact period.

9. It is very desirable that the filter effluents should be collected in a common header and chlorinated before the water enters the clear water basins.

LABORATORY AND PLANT DATA

I shall now state the laboratory experiments and plant operations which substantiate the truth of the above observations. I am speaking of a filter effluent which has been treated prior to filtration with ammonia and chlorine and the final results observed on a filtered water which contains traces of ammonia.

On New Year's Eve, 1933, a distinct chlorinous odor appeared in the city water supply in spite of the fact that the residual chlorine carried in the water was only 0.05. This was overcome by reducing the residual to 0.01 p.p.m and in no way impairing the sterility of the finished product.

In order to overcome the poor bacteriological results mentioned above I decided to collect the treated water samples one and two hours before the tests were run. The two hour period proved successful. Since the establishment of this fact, all treated samples are collected at least two hours before the tests are run and almost 99 per cent of the poor bacteriological results on the treated water have been eliminated.

I discovered, however, that sometimes poor results were obtained in spite of the waiting period established. This led me to follow the residual chlorine in the treated water.

It takes a much longer time to get a maximum coloration with the ortho-tolidin test in ammonia treated waters. A sample after five minutes may show only 0.01 p.p.m. residual chorine, but on standing the shade may become more intense until it reaches a maximum and then gradually disappears.

In the laboratory when the residual chlorine would reach its maximum in a short time and disappear in less than two hours poor bacteriological results would follow. When the residual chlorine lasted for a period of 2 to 2.5 hours the results were very good.

The intensity of the residual chlorine did not matter. A residual chlorine of 0.01 p.p.m. lasting for 2 to 2.5 hours produced just as good results as a residual of 0.05 or more.

Irrespective of how high the residual chlorine would go no odors would appear in the water, provided the residual chlorine would disappear within that period. However, a residual chlorine of 0.02 p.p.m. which persisted in the treated water was sufficient to produce a chlorinous odor when the temperature of the water was raised so that excess air was released at the tap.

From the above observations and experiments I concluded that it is possible to establish a residual chlorine dose which should be based on a definite contact period.

In the case of Bay City the residual chlorine time contact period is 2 to 2.5 hours. At the end of the contact period all residual chlorine must be gone as determined by the ortho-tolidin test. The ortho-tolidin test is made at room temperature.

Where the water reaches the consumer in less than the established contact period the water may not be bacteriologically as safe as in those places that are farther away. It appears essential, therefore, that filter effluents should have a definite contact period with chlorine before they leave the plant. It makes no difference how high or how low the residual chlorine goes as long as the residual chlorine contact period is maintained. It is quite possible that the period will not be the same in all plants, in particular in those places where chlorine alone is used.

COAGULATION WITH ALUMINUM SULPHATE*

By August G. Nolte and Warren A. Kramer

(*Chief Chemical Engineer, Mo. and Senior Chemical Engineer, Chain of Rocks Plant, St. Louis, Mo.*)

The importance of mixing and stirring the water after the addition of the chemicals is being emphasized more and more each year by water works engineers. Laboratory experimentors and plant operators are learning more of the art of stirring and its importance. A great deal of experimental work has been done in this field and a considerable amount written on the subject. A bibliography may be found on pages 20 and 21, Water Works and Sewerage, January, 1931.

Among the earlier workers, observations and conclusions were very diversified. That is also true at the present time to some extent, but the opinions of the leaders are more concordant. Some advocated extremely rapid mixing as the object sought, others that the initial velocity be fairly high followed by a gradual reduction in velocity; some, a moderate velocity for a short period of time and others, a rapid initial velocity followed by a uniform lower velocity.

The conflict among observations made by various experimentors is not due altogether to the character of the water or to the chemical changes, but may be partly attributed to the methods used for measuring and obtaining these velocities in laboratory experiments. The procedure is not standardized, for some measure the velocity at two-thirds the distance from the center of the paddle while others calculate the velocity at the end of the paddle. The size of the container with reference to the size of the paddle also makes considerable differences in results and this phase has received no attention. In plant operation, velocities have been measured by flow meters, floating objects and theoretical calculations. Until a standard method for laboratory and plant practice has been adopted, very close agreement cannot be expected. Comparisons of the

* Study carried on as research work in the Chain of Rocks Laboratory of the St. Louis Water Division.

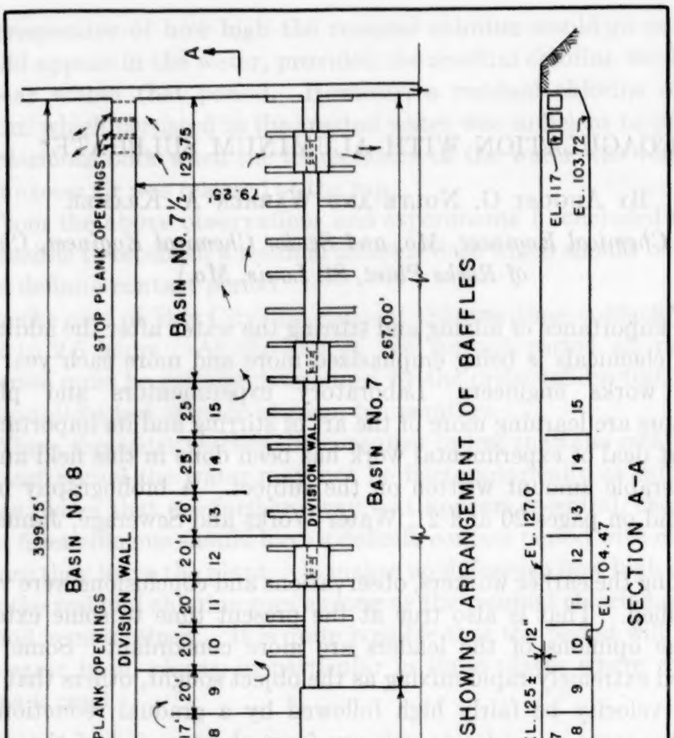

FIG. 1. SECONDARY COAGULATION BASIN No 7½, CHAIN OF ROCKS FILTERS, ST. LOUIS, MISSOURI

results obtained by laboratory experiments with those obtained in plant operation have not been published.

The need for better mixing and conditioning in the secondary coagulation basin no. 7½ at the Chain of Rocks Plant of the St. Louis Water Department had been felt for a number of years past. Improved coagulation could always be obtained by additional stirring of samples of water collected from this basin. The permanent reconstruction of this basin to accomplish better coagulation would have been quite costly. For this reason and on account of the fact that the best method of baffling could not be predicted, it was decided to construct temporary wooden baffles with which to experiment. The general arrangement of these baffles is shown in figure 1. While the arrangement does not give optimum velocities and periods of mixing at all rates of flow, the results obtained thus far show that the baffled basin is superior to the unbaffled one. The filter influent water has been greatly improved and a saving in aluminum sulphate has been effected. The wash water used was reduced 60 percent.

SCOPE OF STUDY

The work outlined in this paper was divided into two parts: (1), the laboratory experiments on coagulation with aluminum sulphate and (2), the comparison of results obtained in the laboratory with those obtained in actual plant operation.

Laboratory Experiments

All water used in this part of the work was collected from basin no. 6, the last of a series of primary settling basins, as needed and in sufficient quantity to complete a series of experiments. In the experiments on optimum velocities and time, the aluminum sulphate charge was determined by adding sufficient aluminum sulphate to reduce the phenolphthalein alkalinity to approximately 10. For example, the alkalinity of the water from basin no. 6, was 23 to phenolphthalein and 47 p.p.m. total. Preliminary experiments showed that $\frac{3}{4}$ g.p.g. of aluminum sulphate produced an alkalinity of 10 p.p.m. to phenolphthalein indicator and 49 p.p.m. total. This charge was used in the experiments unless otherwise stated. Liter samples and, when the higher velocities necessitated the use of larger containers, gallon samples were treated. The velocities used in the experiments varied from 0.15 to 3.0 feet per second. After stirring, the samples were settled and the turbidities read. In some of the

experiments two hours and longer settling periods were discontinued because they did not seem to furnish data of any value. Usually the significant information could be obtained in from 15 to 30 minutes.

When turbidities were obtained for two settling periods and the total period of settling was 2 hours or less, the determination was

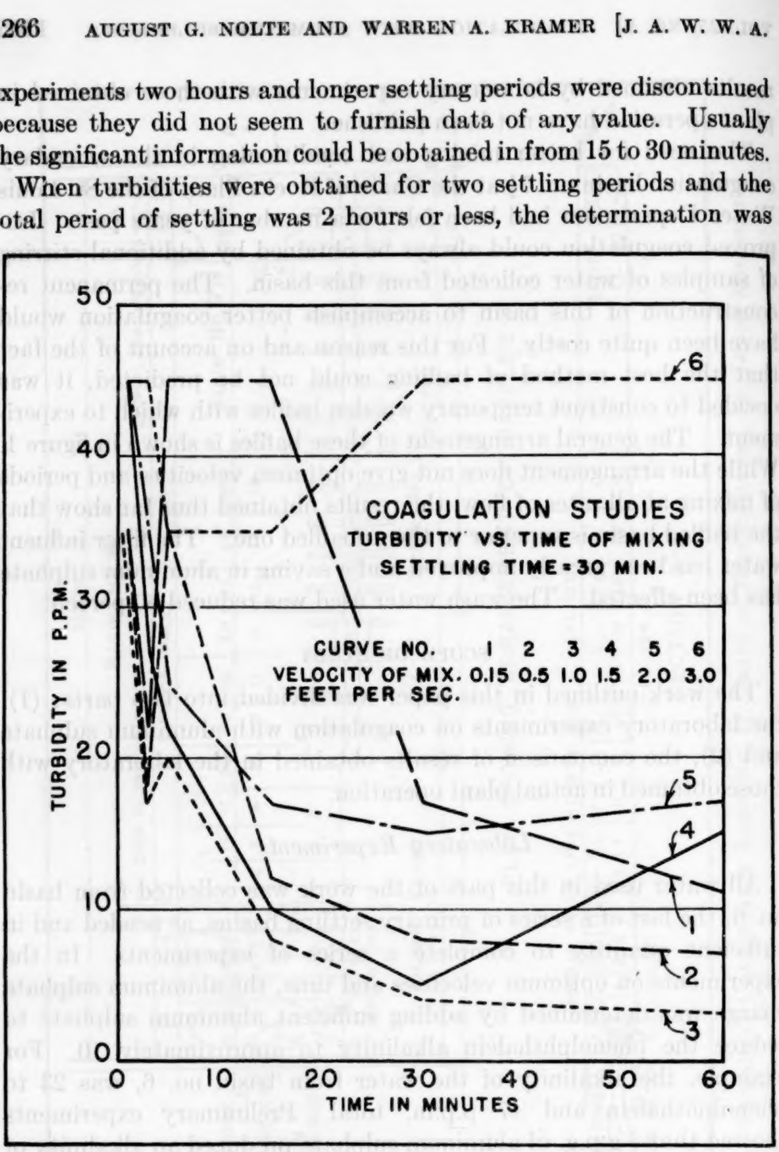

FIG. 2

made on two separate samples. Preliminary experiments showed that a sample ought not be drawn from a jar at the end of $\frac{1}{2}$ hour and another taken 2 hours later, because the floc which has been settling out of the first sample taken from a jar has been dropping down into

the second sample while the floc from the second is falling toward the bottom. The second sample taken from the jar gains almost as much floc as it loses before its turbidity is read. The turbidities were run according to the normal procedure followed in our laboratory. All

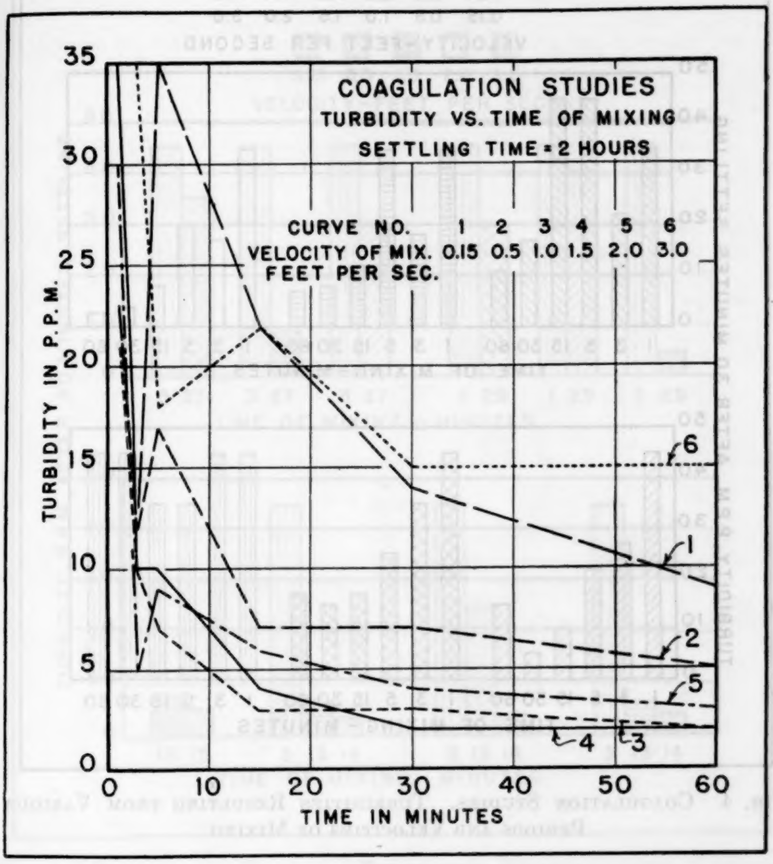

FIG. 3

the stirring was done with the laboratory stirring machine. Variations in velocities were secured by changing the speed of the paddle-shafts and by the use of different length paddles. The velocities were measured two-thirds the distance from the center of the shaft to the end of the paddle. The character of the floc was observed very closely in all cases. Special lights were made to aid in this observa-

tion. These lights were constructed to cast a beam through the solution.

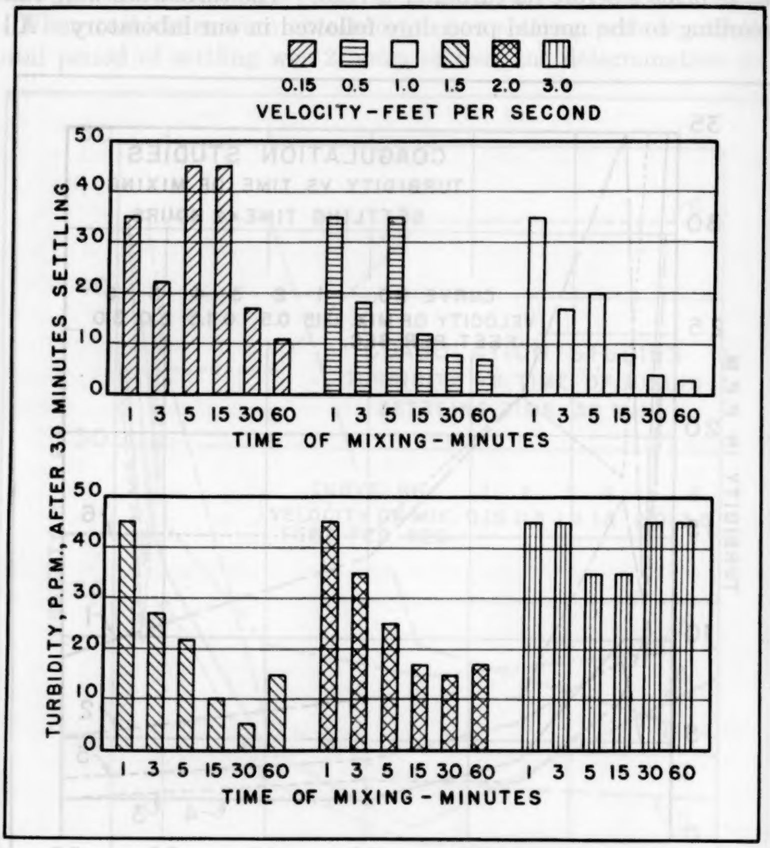

FIG. 4. COAGULATION STUDIES. TURBIDITIES RESULTING FROM VARIOUS PERIODS AND VELOCITIES OF MIXING

The series of experiments on coagulation with aluminum sulphate follows:

(a) Samples of water were treated with $\frac{3}{4}$ g.p.g. of aluminum sulphate and stirred for 1, 3, 5, 15, 30, and 60 minutes at velocities of 0.15, 0.5, 1.0, 1.5, 2.0, and 3.0 feet per second. One series of samples was allowed to settle $\frac{1}{2}$ hour and a second series 2 hours. The turbidities were run at the end of these periods. The results are shown on figures 2 and 3. The results obtained after the one-half hour settling period are shown in greater detail in figure 4.

(b) Samples of water were treated with $\frac{3}{4}$ g.p.g. of aluminum sulphate and were mixed and conditioned as shown below. This series of experiments were conducted to show the results of a short rapid mix followed by conditioning at slower velocities.

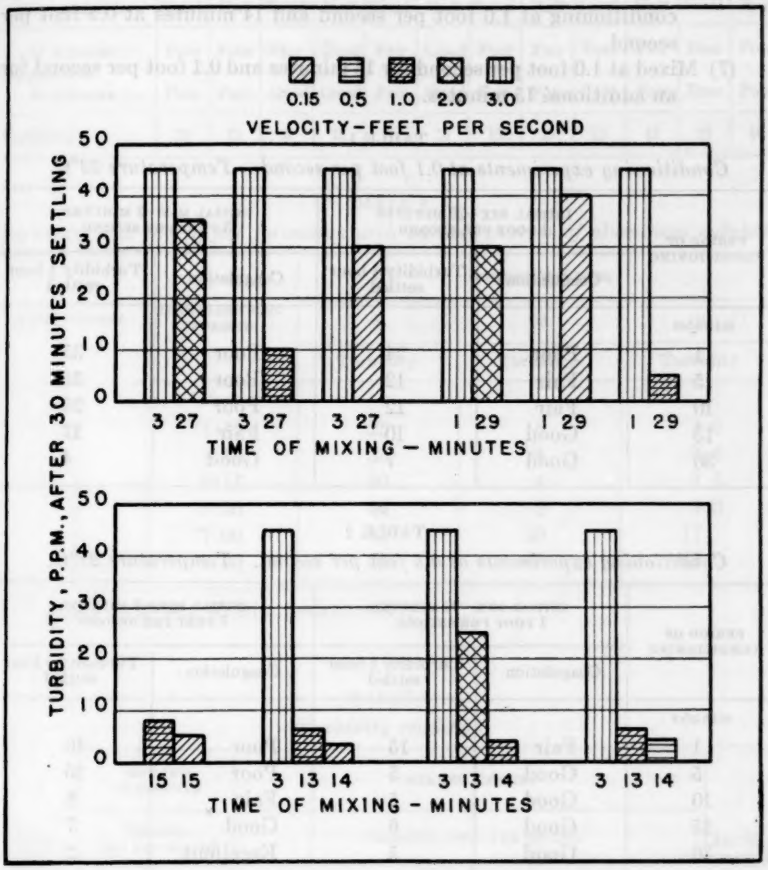

FIG. 5. COAGULATION STUDIES. TURBIDITIES RESULTING FROM VARIOUS PERIODS AND VELOCITIES OF MIXING

(1) One sample stirred at 3 feet per second for 3 minutes was divided into three portions and the stirring continued for 27 minutes at velocities of 2.0, 1.0, and 0.1 feet per second.

(2) Sample stirred for 30 minutes at 1 foot per second and stirring continued another 30 minutes at 0.1 foot per second.

(3) Sample stirred at 3 feet per second for 1 minute, and equal portions conditioned at 2, 1 and 0.1 feet per second for 29 minutes.

(4) Sample stirred for 3 minutes at 3 feet per second, 13 minutes at 1.0 foot per second and 14 minutes at 0.1 foot per second.
(5) Sample stirred for 3 minutes at 3 feet per second, 13 minutes at 2 feet per second and 14 minutes at 1.0 foot per second.
(6) Mixed for 3 minutes at 3 feet per second, followed by 13 minutes of conditioning at 1.0 foot per second and 14 minutes at 0.5 foot per second.
(7) Mixed at 1.0 foot per second for 15 minutes and 0.1 foot per second for an additional 15 minutes.

TABLE 1

Conditioning experiments at 0.1 foot per second. Temperature 22°C.

PERIOD OF CONDITIONING	INITIAL MIX—20 MINUTES 1 FOOT PER SECOND		INITIAL MIX—3 MINUTES 3 FEET PER SECOND	
	Coagulation	Turbidity ½ hour settled	Coagulation	Turbidity ½ hour settled
minutes				
1	Poor	24	Poor	35
5	Fair	12	Poor	35
10	Fair	12	Poor	25
15	Good	10	Fair	17
30	Good	7	Good	4

TABLE 2

Conditioning experiments at 0.5 foot per second. Temperature 21°C.

PERIOD OF CONDITIONING	INITIAL MIX—20 MINUTES 1 FOOT PER SECOND		INITIAL MIX—3 MINUTES 3 FEET PER SECOND	
	Coagulation	Turbidity ½ hour settled	Coagulation	Turbidity ½ hour settled
minutes				
1	Fair	15	Poor	40
5	Good	5	Poor	25
10	Good	5	Fair	8
15	Good	6	Good	7
30	Good	5	Excellent	2

The results of these experiments are shown on figure 5.

(c) Samples of water were treated with ¾ g.p.g. of aluminum sulphate, given various rapid initial mixes and followed by various periods of conditioning. The best and poorest velocities of series (a) were chosen for this work. The object was to determine the optimum rates and periods. The results are recorded in tables 1 and 2.

(d) Samples of water were given a "split" treatment. A set of one liter portions were run in the usual way with ¾ g.p.g. of aluminum sulphate at the indicated velocities and at the same time half-liter portions were run with ¾

TABLE 3

Results of split treatment with aluminum sulphate

VELOCITY FEET PER SECOND	0.15		0.5		1.0		1.5		2.0		3.0	
Alum added to	Total	Half	Total	Half	Total	Half	Total	Half	Total	Half	Total	Half
15 minutes......	Poor	Poor	Fair	Good	Fair	Good	Poor	Fair	Poor	Fair	Poor	Poor
Coagulation												
30 minutes......	Poor	Fair	Good	Good	Fair	Good	Fair	Fair	Fair	Fair	Poor	Poor
Turbidity..........	23	23	5	13	7	13	10	13	15	15	15	30

TABLE 4

Turbidity and rate of floc formation with various charges of aluminum sulphate

ALUM CHARGE	TIME FIRST FLOC FORMED	STIRRED, MINUTES		
		5	20	40
		Turbidity	Turbidity	Turbidity
g.p.g.	*minutes*			
$1\frac{1}{2}$	1:15	25	5	3.5
1	1:15	35	4	3.5
$\frac{3}{4}$	2:15	40	4	3.5
$\frac{1}{2}$	5:00	40	5	4.0
$\frac{1}{4}$	*7:00	45	20	17
$\frac{1}{8}$	*7:00	45	45	45

* Apply to 20 and 40 min. periods only.

TABLE 5

Turbidity readings

INITIAL TURBIDITY	STIRRED 15 MINUTES		STIRRED 2 HOURS						$Al_2(SO_4)_3$ CHARGE
	Velocity, feet per second		VELOCITY, FEET PER SECOND						
	0.15	1.0	0.15			1.0			
	Turbidity	Turbidity	Time 1st floc	Time best floc	Turbidity	Time 1st floc	Time best floc	Turbidity	
			minutes	*hours*		*minutes*	*hours*		*g.p.d.*
35	27	4.5	7	2	4	2	$\frac{1}{2}$	7	$\frac{1}{2}$
22	35	17.0	13		7	2	$\frac{1}{2}$	8	$\frac{1}{2}$
22	22	12.0	13	$\frac{1}{2}$	4.5	2	$\frac{1}{2}$	5	$\frac{3}{4}$
28	27	22	21	2	13	2	$\frac{1}{2}$	20	$\frac{1}{2}$

g.p.g. charge of aluminum sulphate. After 15 minutes the run was stopped, the half-liter portions made up to a full liter, and the stirring continued for 15 minutes more. The samples were settled 30 minutes. The results are recorded in table 3.

(e) Samples of water were treated with charges of aluminum sulphate from 1½ to ⅛ grains per gallon, agitated at 0.5 foot per second for 5, 20, and 40 minutes. The time of first floc formation was noted, the water settled for 30 minutes and the turbidities read. The results are recorded in table 4.

(f) Experiments were run to determine whether the benefit that is lost by optimum velocities could be compensated for by time; that is, if a water is completely coagulated in 20 minutes at 1.0 foot per second, can the complete coagulation be accomplished at 0.15 for a longer period of time. The water was treated with ¾ g.p.g. of aluminum sulphate, stirred as shown in table 5, settled for 30 minutes and the turbidities read.

Comparison of results in the laboratory with those in plant operation

This part of the work consisted of determining the velocity of the water in basin no. 7½ at two rates of flow, namely 60 and 120 m.g.d. and of comparing results obtained in plant operation with those in laboratory experiments in which the chemical charge and the velocity of mixing and conditioning were similar.

The series of experiments on the comparison of laboratory results and plant operation follow:

(a) The velocities of water in basin no. 7½ as found by flowmeter measurements are given in table 6. The velocities were measured at two rates, 60 and 120 m.g.d. The retention periods are calculated from the velocities and the distance the water travels. The retention period is calculated using the average velocity and the maximum velocity in each section. As previously stated the velocity in the sections is not uniform. In the first five sections west of the influent flume the velocity is much greater at and near the surface than it is at the lower levels. This is probably due to the deflecting baffles that direct the water against the filter plant wall and up to the surface as it enters the basin. After the water passes under the influent flume the velocity becomes greatest nearer the bottom in the 6th section, and then becomes greatest again in the shallower depths.

(b) Two sets of samples of water were taken from each of three different locations, namely

(1) From basin no. 7½ where the water, just entering, had received its charge of aluminum sulphate (1⅛ g.p.g.), but had not started to coagulate.

(2) From the opposite end of basin no. 7½ where the coagulation was complete.

(3) From basin no. 6.

The samples from location (1) were mixed and conditioned in the laboratory at the same velocities and periods as the water was being mixed and conditioned in basin no. 7½ and then settled 30 minutes and the turbidities read.

The samples from location (2) were allowed to settle 30 minutes in the laboratory and the turbidities read. The samples from location (3) were treated with $1\frac{1}{8}$ g.p.g. of aluminum sulphate, mixed and conditioned in the laboratory at

TABLE 6

Basin No. 7½—distances and velocities through its sections, and the corresponding retention periods

SECTION NO.	WIDTH OF CHANNEL	DISTANCE WATER TRAVELS	60 M.G.D. FILTRATION				120 M.G.D. FILTRATION			
			Av. Vel. in Sections	Retention Period	Max. Vel. in Sections	Retention Period	Av. Vel. in Sections	Retention Period	Max. Vel. in Sections	Retention Period
	feet	*feet*	*ft./sec.*	*hrs.-min.-sec.*	*ft./sec.*	*hrs.-min.-sec.*	*ft./sec.*	*hrs.-min.-sec.*	*ft./sec.*	*hrs.-min.-sec.*
2	10		0.31		0.63		0.97		2.58	
3	10		0.31		0.75		1.06		2.87	
4	10		0.29		0.71		0.84		1.99	
Ave.	10	240	0.30	0-13-20	0.69	0- 5-48	0.96	0- 4-10	2.45	0- 1-38
5	13		0.05		0.48		0.28		1.62	
*6	13		0.30		0.42		0.39		0.67	
Ave.	13	122	0.17	0-11-58	0.45	0- 4-31	0.33	0- 6-10	1.15	0- 1-46
7	15		0.18		0.54		0.46		1.26	
8	17		0.14		0.39		0.40		0.91	
Ave.	16	164	0.16	0-17- 5	0.47	0- 5-49	0.43	0- 6-21	1.09	0- 2-30
9	20		0.09		0.38		0.37		1.15	
10	20		0.10		0.31		0.38		0.79	
11	20		0.10		0.29		0.36		0.81	
12	20		0.07		0.33		0.44		0.95	
13	20		0.07		0.28		0.40		0.84	
Ave.	20	391	0.09	1-15-46	0.32	0-20-21	0.39	0-16-43	0.91	0- 7- 9
14	25		0.04		0.26		0.24		0.55	
15	25		0.04		0.19		0.34		0.72	
Ave.	25	144	0.04	1-00-00	0.23	0-10-26	0.29	0- 8-20	0.64	0- 3-45
Totals		1061		2-58- 9		0-46-55		0-41-44		0-16-48

* The influent conduit passed through between sections 5 and 6.

the same velocity and periods as the water received in basin no. 7½ and then settled 30 minutes and the turbidities read.

The above procedure was carried out with one set of samples using the average rate of flow in the various sections while with the other set the maximum rates of flow were used in the laboratory stirring procedure. The rates

TABLE 7

Comparison of turbidities found in water after mixing in basin 7½ and in laboratory

	MAXIMUM VELOCITIES 60 M.G.D.			AVERAGE VELOCITIES 60 M.G.D.		
Sample No.	1	2	Settled	1	2	Settled
			minutes			*minutes*
*7½ not coagulated	4	4	30	4	4	30
7½ coagulated	5	5	30	4	4	30
Basin 6	4	4	30	4	4	30

* Coagulated in laboratory.

TABLE 8

Turbidities after stirring and settling at various rates with different charges of aluminum sulphate

VELOCITY FEET PER SECOND	SAMPLE FROM BASIN 7½—CHANNEL 1—STIRRING DONE IN LABORATORY—20 MINUTES					
	$Al_2(SO_4)_3$ charge 1⅓ g.g.d.		$Al_2(SO_4)_3$ charge ⅝ g.p.g.		$Al_2(SO_4)_3$ charge ½ g.p.g.	
	30 minutes	18 hours	30 minutes	24 hours	30 minutes	24 hours
0.0	30	4	50	4	22	5
0.04	45	5	50	4	22	5
0.09	35	5	50	4	22	5
0.15	7	4	40	4	25	5
0.5	4	3	10	4	17	5
1.0	2	2	8	4	15	5
1.5	2	2	10	4	17	5
2.5	5	2	15	4	17	5
3.0	6	2	22	4	35	5

TABLE 9

Table showing improvement of floc in basin no. 7½ by stirring

RATE FILTRATION	$Al_2(SO_4)_3$ CHARGE	VELOCITY FEET PER SECOND				TEMPER-ATURE
		0	0.15	0.5	1.0	°C.
m.g.d.	*g.p.g.*					
59.2	¼	35	17	17	25	18
59.2	¼	35	35	23	23	19
49.4	½	12	7	3.5	12	16
49.4	¾	6	5	4	7	17
78.0	⅞	12	5	4	5	17

for stirring were taken from table 6. The results of this series of experiments are shown in table 7.

(c) Samples from basin no. 7½ containing the coagulant, but not yet coagulated, were stirred in the laboratory for 20 minutes at various rates and allowed to settle. The results of this series are shown in table 8.

(d) Liter samples of water were collected from the effluent end of the last baffle in basin 7½ after the water had received all the stirring it could receive in the basin. The samples were carefully carried to the laboratory and the stirring continued on the laboratory machine. The samples were stirred 20 minutes and settled 15 minutes. The results are recorded in table 9.

DISCUSSION OF RESULTS

An examination of figures 2, 3 and 4 shows that good results can be obtained with velocities from 0.5 to 1.5 feet per second for 30 minutes. For the 30 minute settling period the lowest turbidity was reached after stirring at 1.0 foot per second for 60 minutes. However, the slight improvement made by stirring 60 over 30 minutes is so small that the 60 minute period would not be justified.

A 60 minute period at 1.5 feet per second apparently breaks up the floc after it has formed. Velocities greater than 1.5 feet per second for any period from one to 60 minutes give poor results. These velocities are undoubtedly too high to allow the floc to form in large particles, but keep it broken into small particles.

If the water is allowed to settle two hours or more in a jar undisturbed, the turbidities tend to become more nearly equal. This is shown in figure 3. In a basin, however, where there is a flow of water, the fine floc will not settle. A large floc that will settle rapidly after it enters the settling basin is the object to be sought.

A water that will settle to a turbidity of 5 p.p.m. in 30 minutes after mixing shows a greater efficiency from the aluminum sulphate and mixing than a water that settles to the same turbidity in a greater length of time. To get the maximum efficiency from a coagulant, it must be properly coagulated and a large flocculent precipitate must be formed in the mixing chamber.

On figure 5 the results of a short rapid mix followed by reduced velocities of conditioning can be observed. Sufficient variations are covered in these experiments to draw definite conclusions on what might be attained in practice by this process. Mixing the water at a high velocity for a short time and reducing the velocity to 1.0 foot per second, give results that are comparable with uniform velocities of 0.5 to 1.5 feet per second over the same period of time. There is

no harm done in mixing the chemicals in this manner provided the initial mix at these high velocities is for a short period, one to three minutes. There are no advantages to be attained by this procedure and if the baffle system is used to obtain these high velocities of initial mix there are several reasons why this method should not be practiced. The narrow channels necessary to produce these velocities cause a tremendous loss in head. No control can be maintained over such a system when the velocities are governed by the rates of filtration. Everyone will agree that the chemical should be thoroughly distributed through the water. In the baffle system this can be accomplished by uniformly distributing the chemical through a manifold over the entire volume of water in the mixing conduit. Mixing at decreasing velocities as practiced in our present basin 7½ baffle system has no advantages over mixing and conditioning at uniform velocities. The incorporation of "bottle necks" or so-called quick mix baffles have no place in a modern water purification system.

Tables 1 and 2 are additional experiments showing the effect of conditioning the water at lower velocities. The velocities that gave the best results as shown on figure 2 were chosen and after mixing at these velocities they were further mixed at lower rates. Velocities giving the poorest results as shown on figure 2 were also chosen and the mixing continued at uniform lower velocities. In all cases the water was improved by the conditioning after the rapid mix. In no case did the improvement surpass the results obtained by uniform mix to justify such a system of mixing.

Certain observations indicated that there might be some advantage to applying split treatment to the coagulant. That is to add the aluminum sulphate to half of the water, agitate until the floc was completely formed, and then add the remaining water. The results of this experiment given in table 3 show that nothing is to be gained by applying the aluminum sulphate charge in this manner.

Several observations can be made from table 4. The higher the charge of aluminum sulphate, the more rapidly the floc is formed. For this reason lower charges of aluminum sulphate will require longer periods of agitation. This has previously been shown by Buswell, "The Chemistry of Water and Sewage Treatment," page 169. However, after the aluminum sulphate has completely coagulated, prolonged stirring will not improve the water, in other words a deficiency in aluminum sulphate charge cannot be compensated for by prolonged stirring. There is a certain optimum

charge of aluminum sulphate for every water. A deficiency of this charge will give poor results regardless of the agitation. An overcharge may not result in any harm, but it is extremely wasteful. In this case ½ g.p.g. of aluminum sulphate was the proper dosage. The coagulation was complete in 20 minutes, longer periods of agitation were useless and greater charges were wasteful, for no better results are obtained with 1½ than with ½ grain. On the other hand, with less than ½ grain per gallon the water could not be properly settled. The results of insufficient mixing are also brought out in this table, the five minutes stirring giving very poor results compared to the 20 minute mix.

Water could not be properly coagulated at low velocities in time that was practical in plant operation, as shown in figures 2 to 5. The results recorded in table 5 confirm this. The benefit that is lost by agitation at low velocities can be made up to some extent by a longer time of mixing. For the 15 minutes mix the 1.0 foot per second velocity gives much better results. Two hours mixing at 0.15 foot per second, give results that are comparable to those at higher velocity for shorter periods.

At first inspection of table 7, it may seem strange that the results obtained are so nearly in agreement. At the time these experiments were made very good results were being attained in basin 7½. It is quite impossible to duplicate in the laboratory the exact movement in basin 7½. This fact will be recognized from an inspection of table 6 of velocities in this basin. The high and low velocities of table 7 are those taken from table 6 at the 60 m.g.d. rate. If the velocities in these columns be averaged it will be found to be 0.15 foot per second for a retention period of 2 hours 58 minutes and 9 seconds, and 0.45 foot per second for a retention period of 46 minutes and 55 seconds. Previous experiments have shown that good coagulation resulted with 0.5 foot per second for 30 minutes and 0.15 foot per second for 2 hours, so that it is not surprising to find that the results in table 7 are all good and so nearly alike.

In table 8 it will be observed that the best results were always obtained at velocities from 0.5 to 1.5 feet per second. This is true whether the charge is 1⅛, ⅜ or ¼ grains per gallon. These experiments as well as those discussed above all point to the fact that to coagulate the water in a short period of from 20 to 30 minutes velocities of from 0.5 to 1.5 feet per second are required.

Previous to the time the baffles were built in basin 7½ it was demon-

strated on many occasions that the water could be improved by additional stirring. Additional improvement can still be shown any time samples are collected. At some times more improvement can be shown than at others. Table 9 gives some examples. These samples were collected at a time when the results obtained in basin $7\frac{1}{2}$ were the best ever obtained, yet improvement in the floc can be made.

(Presented before the Missouri Valley Section meeting, October 26, 1932.)

LABORATORY CONTROL FOR WATER WORKS

By Charles P. Hoover

(Division of Water, Columbus, Ohio)

The operation and control of any plant is tremendously simplified if it is built to handle satisfactorily the water that must be treated. Chemical, bacteriological and microscopical analyses, and studies of a proposed supply should, therefore, be made before the plant is built. These tests are especially necessary if the water of the proposed supply is highly turbid, highly colored, or, resistant to coagulation or water softening precipitation. The information obtained from these analyses and tests is of use not only in helping to design the right kind of a plant, but in making a choice if more than one supply is available. A permanent record of the results of complete analyses of the alternate supplies may be of considerable value to the water department. Special care should be exercised in selecting samples that show the character of the supply under unusual as well as under normal conditions. If the water is to be taken from more than one well, each well should be tested separately, because the results of analyses of water from different wells in the same underground supply and drilled to the same depths, often show great differences in mineral content.

WHAT ANALYSES AND TESTS SHOULD SHOW

The chemical analysis should include: Substances of mineral origin, such as turbidity, silica, iron, manganese, alumina, carbonates, bicarbonates, sulfates, chlorides, nitrates of calcium, magnesium and sodium together with color, odor, taste, pH, alkalinity, hardness, free CO_2, H_2S, and chemical balance. The bacterial analysis should show: Total numbers of bacteria and B. coli, and the microscopical analysis: Algae, diatoms and other plant forms.

The sedimentation, coagulation and water softening experiments when made in the laboratory, should be conducted as nearly as possi-

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ble according to procedures that can be duplicated in plant operation. The results of these analyses and tests should show the necessity for or the lack of need for aeration, presedimentation, iron or iron and manganese removal, taste elimination facilities, and they should also show what coagulant or coagulants are best suited for color and turbidity removal, the quantity required, if more than one is used the order in which they are most advantageously applied, the need for pH adjustment, intensity and time of mix, coagulation and settling periods required, and, in the case of water softening, the most economical and best suited process to be adopted together with the kind and cost of softening reagents required.

LABORATORY CONTROL FOR WELL SUPPLIES

The large majority of water works in the smaller cities of the middle-west, meaning communities having from 1000 to 10,000 population, are supplying their consumers with well water and do not have any kind of a treatment plant.

What routine test or tests should be made on these supplies? Every public water supply, no matter how small or how satisfactory the source of supply is supposed to be, should be tested regularly for presumptive B. coli in order to know at all times whether or not it is bacterially safe for human use. This test can be made by any reliable pumping station operator after some training, in less than five minutes time. Where laboratory facilities are not available, it is sometimes made as follows: The operator procures the lactose fermentation tubes filled with 30 cc. of broth prepared ready for use. The test tubes holding the broth are calibrated with two marks (usually deep file marks), one indicating 30 cc. capacity and the other 40 cc. Each tube, as received by the operator, is filled to the 30 cc. mark with lactose broth and the presumptive B. coli test is made by removing the cotton plug from the tube, and allowing slowly running water from the tap to fill the tube to the second calibration mark. In other words, 10 cc. of the water to be tested is added. The inoculated tube is then incubated at 37°C. for 24 and 48 hours and the absence or presence of gas formation (i.e., B. coli) is recorded. It will be noted that the only equipment required is a 37°C. incubator. Some small plants, where electric current is not available, use chicken incubators.

If chlorine is used, the operator should make not only the presumptive B. coli test, but also determine regularly the residual chlorine in the treated water. The value of chlorine as a treatment process

for protecting public water supplies has been well established. Unfortunately, however, it is unpopular with water consumers. The most recent complaint against its use is that it spoils "home-brew." The real prejudice however arises from the fact that it produces an unpleasant taste in the water when applied in sufficient quantity to produce too much residual chlorine. It is perhaps not possible to eliminate entirely occurrences of chlorine tastes in chlorinated water supplies, but frequent testing should reduce these occurrences to a minimum.

The test for residual chlorine is a very simple one, does not require expensive equipment and it not only indicates to the operator whether enough or too much chlorine is being added but it also enables him to detect quickly whether or not the chlorine apparatus itself is functioning properly.

CONTROL FOR MECHANICAL FILTER PLANTS

The following tests and recorded observations should of necessity be made as a routine procedure for the control of all filter plants that treat surface supplies.

1. Quantity of water treated.
2. Length of filter runs between washings.
3. Percent wash water used.
4. Quantity of chemicals used and rate of application.
5. Alkalinity of raw and filtered water.
6. Turbidity of raw and filtered water.
7. Color of raw and filtered water.
8. Residual chlorine in chlorinated water.
9. Total number of bacteria; settled, filtered and chlorinated samples.
10. Presumptive B. coli; settled, filtered and chlorinated samples.

Other tests may be even more important than some of those listed above, but whether or not it is necessary or unnecessary that they be made as a part of the routine schedule depends on the character of the water treated. It will not be possible in this paper to go into all the special problems involved in water purification and indicate what routine tests should be made in special cases or why each test should be made, but a few will be cited. For instance, tastes and odors are apt to develop in reservoirs due to algae growths. The development of these growths may be satisfactorily retarded or killed by copper sulfate treatment and the occurrence of bad tasting water may possibly be prevented if the operator learns from the results of micro-

scopical analyses or plankton net tests the extent of the growth and is able to apply corrective treatment before the trouble actually starts.

The water may be corrosive to the distribution system and in the treatment of such supplies it is necessary to maintain chemical balance. Water that is saturated or super saturated with calcium carbonate will deposit a coating or incrustation on the inside of the pipe and such water is not apt to be corrosive whereas water that is under saturated with calcium carbonate is apt to be corrosive.

The chemical balance test is made as follows: The sample of water to be tested is divided into two parts, 1 and 2. The alkalinity to methyl orange on sample No. 1 is determined and the result obtained recorded. To sample No. 2, (say 150 cc.) a considerable excess of calcium carbonate is added, then stirred a few minutes, settled, filtered and the alkalinity determined. If the alkalinity of sample No. 2 is higher than the alkalinity of sample No. 1, the result shows that the water is under saturated. If the alkalinity is exactly the same on both samples, this would indicate that the water is neutral to calcium carbonate, that is, it will neither dissolve nor deposit calcium carbonate. If on the other hand, the alkalinity of sample No. 2 is lower than the alkalinity of sample No. 1, then the sample is super saturated with calcium carbonate and will deposit scale.

Turbidity or color of some water supplies changes frequently, or, the water for no very apparent reason, may occasionally resist coagulation. It may therefore become necessary to make coagulation tests often in order to determine the minimum quantities of coagulant or coagulants required to effect satisfactory coagulation, color removal and sedimentation. This test is usually referred to as the jar test. It consists of adding measured quantities of the coagulant to measured volumes of the raw water, then stirring at a velocity of about 1 foot per second for 30 minutes, settling for 30 minutes and then filtering the settled water through a paper filter. Usually the minimum quantity of coagulant that produces a bright sparkling, low colored effluent from the paper filter is the quantity that will produce satisfactory results in plant operation. When making these jar tests the pH of each treated sample should be recorded and the pH at which best floculation occurs should be carefully noted. Having determined the pH at which best results are obtained, it is easy to check and also easy to maintain the plant treated water at that pH.

In the operation of any plant, after the proper dosage of coagulant or coagulants is determined, the actual rate of application should be

checked regularly. Some of the newer dry feed machines for applying chemicals are built on weighing scales or the hoppers holding the chemicals above the machines are suspended from scales so that the quantity of chemicals discharged from them over any time period is indicated. Knowing the quantity of chemical discharged over a time period, and the pumpage, the rate of application can be readily computed.

With dry feed machines not so equipped, the material discharged from them over a timed period may be caught in a receptacle and weighed. If the chemicals are fed from a solution tank the rate of application may be computed by measuring the flow. This is usually done by measuring the drop of solution in the tank over a unit of time. The strength of the solutions may be checked roughly by a hydrometer, or, as suggested by Willard Harper*, by making the strength of the solution such that 1 cc. of it is equivalent to 1 grain (a 7 percent solution is approximately this strength). Its reaction when stirred with a sample of water in the jar test can be compared with a standard solution of similar strength.

CONTROL FOR IRON REMOVAL PLANTS

Iron is usually removed from ground water, by aeration followed by settling, then filtering through sand filters, or, it may be aerated, then treated with enough lime to neutralize the CO_2, followed by sedimentation, or, sedimentation and filtration. Plants of this type are preferably built similar to a water softening plant, and may be operated as an iron removal plant, or, if desired, readily converted into a softening plant by the addition of some extra equipment.

Two special processes have recently been advocated for the removal of iron from ground water. The first one consists in filtering the water through a mineral that oxidizes and filters out the iron. When the mineral becomes exhausted and fails to remove the iron, it is reoxidized with potassium permanganate. The second process consists in oxidizing the iron with chlorine, then removing it by sand filtration and dechlorinating the effuent by filtering through activated carbon.

The older processes require that the water be pumped twice; first from the wells through the iron removal plant; and second, from the iron removal plant into the distribution system. Special processes are designed to eliminate the second pumpage.

The laboratory control for iron removal plants does not differ

materially from that of an untreated well supply except that tests for iron should be made. Iron removal is usually considered as being satisfactory if no appreciable visible quantity of iron is precipitated from the water within 24 hours after treatment.

If lime treatment is used it is advisable to make alkalinity determinations with both methyl orange and phenolphthalein. If this is not done the efluent should be tested by adding a few drops of phenolphthalein indicator to it to make sure that not more than a trace of color is produced.

CONTROL FOR LIME OR LIME SODA-ASH WATER SOFTENING PLANTS

If the softening plant is treating surface water, the laboratory control will be much the same as for a mechanical filtration plant with the addition of a few extra tests added as a part of the laboratory routine.

If satisfactory softening results are to be obtained, the water must be treated with the right amounts of lime and soda-ash and properly recarbonated. The most recently built softening plants, especially if built to soften surface supplies, are built with two mixing tanks, two clarifying basins and two carbonators. If the water is extremely muddy a coagulant is first added to it in the first mixing tank and the mud is removed in the first clarifier basin. The water then passes to the second mixing tank where the softening chemicals are added The quantity of lime and soda required to soften the water is not always the right amount needed to effect satisfactory flocculation of muddy water. Therefore, it is advisable to remove or partially remove the mud before attempting to soften. After the mud has been removed, the water passes successively to the second clarifier, the second carbonation basin, and finally to the filters. When the water is not especially muddy the course through the plant is usually as follows:

1. No. 1 mixing tank.
2. No. 1 clarifier.
3. No. 1 carbonator.
4. No. 2 mixing tank.
5. No. 2 clarifier.
6. No. 2 carbonator.
7. Filters.

In addition to the tests outlined for filtration plants it is advisable to run frequent tests (i.e., every few hours) for alkalinity (methyl

orange and phenolphthalein) on samples collected at the outlet of the first mixing tank, the first carbonator and the outlet of a filter in service. Samples of the raw and filtered water should also be tested at least once daily for alkalinity and hardness, and, hardness determinations should be made at regular intervals from samples at the outlet of the first mixing tank.

Perhaps the most important tests made are those on the samples from the first mixing tank which should be made on the samples after heating them to 50°C. (122°F.). The reactions at this point in the treatment process are not usually completed, and, do not mean much unless the reactions are hastened by heat. The lime feed is usually satisfactory if twice the alkalinity to phenolphthalein exceeds the alkalinity to methyl orange by from 10 to 50 p.p.m.

The first carbonation is considered satisfactory if twice the alkalinity to phenolphthalein is somewhere near the total alkalinity.

The outlet of the filter should show preferably from 1 to 5 p.p.m. of phenolphthalein alkalinity, and about 35 p.p.m. total alkalinity and a total hardness not exceeding 70 to 85 p.p.m. or 4 to 5 grains per gallon.

CONTROL FOR ZEOLITE PLANTS

Zero softened water when pumped through a distribution system is apt to be unsatisfactory because of red water troubles. This is true especially in the case of hot water heaters. Zeolite softened water, for general municipal use, should have its pH value and calcium carbonate content adjusted so that it is in chemical balance to calcium carbonate.

The pH may be raised by aeration to eliminate CO_2, or by the addition of an alkali. The calcium carbonate content necessary to obtain chemical balance is usually obtained by by-passing a portion of raw water around the softener.

Water containing free carbon-dioxide and free from iron and oxygen will readily dissolve precipitated iron or iron nodules already formed in a distribution system. Highly carbonated, oxygen-free well water pumped through zeolite softeners may be entirely free from iron as it leaves the softener, but if pumped through an already corroded distribution system, the immediate results will not be satisfactory to the water consumer and presumably will not be until after all the rust in the distribution system has been dissolved or washed out.

If the water is partially oxidized by aeration and the pH and the

calcium carbonate balance adjusted, almost immediate satisfactory results should be obtained.

The principal routine test usually made at zeolite softening plants is the soap test. It is made to determine when a softening unit is exhausted and when it has been sufficiently backwashed following regeneration. When the water discharging from the softener begins to show a noticeable amount of hardness as measured by the soap test, it is usually considered time to regenerate. When the rinse water used for washing the salt out of the softener, shows less than 20 p.p.m. hardness shown by the soap test, the softener is considered ready to be put back into operation.

After softening capacity and salt requirements of a softening unit have been established, it is very necessary to keep records so as to know whether or not the unit is holding up to its softening capacity and salt requirement. Any diminution in capacity usually indicates packing of the zeolite or channeling of the water through the bed.

(*Presented before the Illinois Section meeting, April 13, 1932.*)

LACTOSE FERMENTING ORGANISMS IN PHILADELPHIA'S DRINKING WATER

By George G. Schaut
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In a previous article* the writer attempted to show that gas formation in lactose broth had no relation to the true B. coli index of the water. Some attempt was made to classify the gas forming organisms.

Thinking their separation into only two groups (aërobic and anaërobic) and time periods of 24 and 48 hours would be of some value in relation to evaluating the various purification processes in use today led the author to compile the data herein presented.

The bacteriological work consisted of primary inoculation of five 10 cc. portions of water into lactose broth daily, noting the gas formation at the end of 24 and 48 hours. (Standard A. P. H. A. Methods were used). Practically no tests were encountered that showed less than 10 per cent gas in 48 hours. Those tubes showing gas were plated on eosin methylene blue agar and growth noted. Where no growth appeared on eosin methylene blue agar after 48 hours incubation at 37°C. the gas was diagnosed as being produced by strict anaërobes. The 24-hour aërobes were, with few exceptions, typical B. coli as found by the completed test. The 48-hour aërobes cannot be considered as strictly aërobes, for all growths on eosin methylene blue agar plates were considered aërobic, while as a matter of fact many were facultative anaërobes. This 48-hour aërobic group contained very few colon group organisms. Most of them did not produce any gas in 24 hours and 50 to 90 percent of gas in 48 hours and failed to confirm by the completed test, for, in most cases spores were found. Very few of the organisms found in this 48-hour aërobic group fermented 2 percent brilliant green bile. With this information at hand it is easy to understand why the B. coli index of the water supplied to the consumers of Philadelphia will invariably average less than 1 per 100 cc.

* Journal, April, 1929, page 531.

SOURCES OF SUPPLY

The water supplied to the City of Philadelphia is drawn from two rivers, i.e., Delaware and Schuylkill. In chemical composition they are quite different as the Schuylkill River receives coal mind drainage and flows through a limestone region thus making its mineral constituents about twice those of the Delaware. The Delaware River receives some mine drainage, but the volume of flow of the river is so many times greater than the Schuylkill River that the effect of mine drainage is almost nil.

Both rivers receive raw and treated sewage (table 1) and some sanitarians when investigating the municipal water supply like to call the rivers open sewers, but actually they are not quite as bad as that. The intake for the Torresdale Filtration Plant is located on the Delaware River, while the Schuylkill River contains intakes for the other three plants located a mile or so apart and on different sides of the river.

TABLE 1
B. coli index—raw waters
(Probable organisms per 100 cc.)

INTAKE	1929	1930	1931
Belmont	18,400 Mn.	11,700 Mn.	13,500
Queen Lane	24,000	16,800	16,500
Roxborough	32,700 Mx.	23,200 Mx.	21,700 Mx.
Torresdale	20,800	18,500	13,400 Mn.

Mx., symbol for maximum.
Mn., symbol for minimum.

The Torresdale Filtration Plant consists of short preliminary sedimentation, mechanical pre-filters without the use of alum followed by slow sand filters and post chlorination. All the water is doubly filtered.

The Queen Lane Filtration Plant consists of two separate processes having a common intake and a partial mixing of the finished water before going to distribution. The raw water is about equally divided and that which finally reaches the filtered water basin has passed through the same process as used at Torresdale and flows into the South Basin. There is an equalizing gate between the South and North Basins so, depending upon the water elevation one may flow

into the other. Most of the time the South Basin contains water from slow sand filters. The other 50 percent of the water at Queen Lane goes through a typical rapid sand plant consisting of very short preliminary sedimentation, alum treatment, mixing chambers, coagulation basins, prechlorination, rapid sand filters and is then mixed with some water from the slow sand filters in the North Basin and chlorinated before going to distribution. The water passing through the rapid sand plant receives double chlorination and a residual chlorine is carried entirely through the sand of the rapid sand filters which, should prevent any after-growth in the underdrain system. The tests on North Basin water must not be looked upon as being representative of all rapid sand water, but the rapid sand water predominates. The chlorine dosage of this water is double that applied to the other plant effluents. These two units making up the Queen Lane plant, being run in parallel and using the same raw water, afford an excellent means of comparison.

The Belmont Filtration Plant consists of two separate processes having a common intake and partial mixing of the water before going to distribution. The water for both processes passes through a common preliminary sedimentation basin of short retention period and then divides about equally. One-half of the water receives alum and lime treatment and passes through mixing chambers, coagulation basins, rapid sand filters and is then chlorinated before going to distribution. The other half of the water at Belmont flows from the sedimentation basin through slow sand filters and is then chlorinated. Some of the water from the rapid sand units is mixed with the slow sand water in the slow sand filtered water basin. Thus, all tests made upon the water in the slow sand basin must be looked upon as not directly applicable to slow sand water alone, to be due to about a half and half mixing. The tests on the water in the rapid sand filtered water basin afford an excellent means of studying a straight rapid sand plant as the water is not mixed.

The Upper Roxborough Filtration plant consists of long preliminary sedimentation, slow sand filtration and post chlorination.

COMPARISON OF RESULTS

This study covers a rather unique period of time as far as climatic conditions are concerned, for without the data for the year 1930 one might be inclined to place less value on the study as a whole. The year 1930 will be remembered as the year of the great drought. It

was the greatest drought in the history of the local weather bureau. The people in Philadelphia, as far as water was concerned at that time, never felt the effect of the drought as no one was asked to conserve water in the city proper. This is certainly a good reason to be nearer the mouth than at the head waters of a stream. The year 1929 was a normal year, while 1931 showed temperatures much above the average. As a matter of fact the summer was extremely hot and even up until Christmas the winter was very mild.

The various purification processes may be compared in table 2. Only the percentage of total gas forming organisms is shown. The author does not wish to convey the idea that these figures are confirmed positives. Neither are the values in figure 1, for they simply

TABLE 2

Presumptive B. coli tests (for various purification processes)

	PERCENT POSITIVE		
	1929	1930	1931
Belmont filtered water basin	34	25	29
Belmont rapid sand filtered water basin	33	25	33
Queen Lane south basin	40	29	20 Mn.
Queen Lane north basin	42 Mx.	34 Mx.	44 Mx.
Upper Roxborough filtered water basin	27 Mn.	20 Mn.	20 Mn.
Torresdale filtered water basin	42 Mx.	31	36

Mx., symbol for maximum.
Mn., symbol for maximum.

represent tests that have shown 10 percent of gas or over in 48 hours. Whole numbers are used in figuring the percentages as the technique and the probable error of the determinations do not warrant any greater accuracy. To attempt to tabulate the anäerobic and aërobic would involve too much detail for the average reader. The proportion in which these gas forming organisms occur, together with their seasonal as well as yearly variation is best observed in figure 1. The most efficient type of purification is the plant with long preliminary sedimentation and slow sand filtration, whereas the type of plant in vogue today—double chlorination and rapid sand filtration—is the least efficient as far as delivering a water free of gas forming organisms.

In order to arrive at average figures for the Schuylkill in compari-

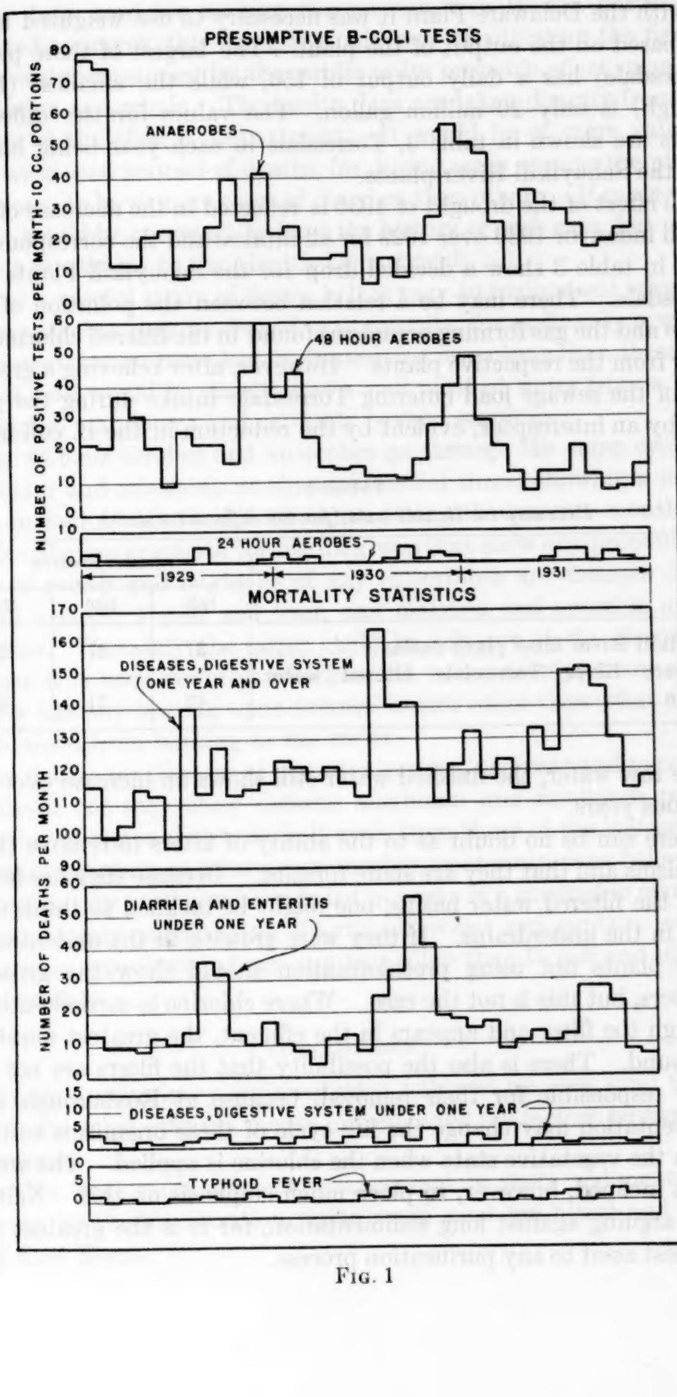
PRESUMPTIVE B-COLI TESTS
NUMBER OF POSITIVE TESTS PER MONTH–10 CC. PORTIONS
ANAEROBES
48 HOUR AEROBES
24 HOUR AEROBES
1929
1930
1931
MORTALITY STATISTICS
NUMBER OF DEATHS PER MONTH
DISEASES, DIGESTIVE SYSTEM ONE YEAR AND OVER
DIARRHEA AND ENTERITIS UNDER ONE YEAR
DISEASES, DIGESTIVE SYSTEM UNDER ONE YEAR
TYPHOID FEVER

FIG. 1

son with the Delaware Plant it was necessary to use weighted averages based on the output of the plant. The largest of these plants (Torresdale) has a daily output of 150, while the smallest (Roxborough) is only 20 million gallon. The values for the different waters are shown in table 3, Torresdale in each year being higher than the Schuylkill River plants.

The effect of the drought of 1930 is reflected in the decrease of the B. coli index for 1930 over 1929 for all intakes and the corresponding years in table 3 show a decided drop for the Schuylkill Plants and Torresdale. There may be a relation between the pollution of the source and the gas forming organisms found in the filtered chlorinated water from the respective plants. However, after relieving a greater part of the sewage load entering Torresdale intake during the year 1931 by an interceptor, evident by the reduction in the B. coli index

TABLE 3

Presumptive B. coli tests (for the different waters)

	PERCENT POSITIVE		
	1929	1930	1931
Schuylkill River filter plant basins	37	27	28
Delaware River Torresdale filtered water basin	42	31	36

of the raw water, the finished water still shows an increase over the previous years.

There can be no doubt as to the ability of filters to remove these organisms and that they are spore forming. Because they are found in all the filtered water basins, one might be inclined to think they grow in the underdrains. If they were growing in the underdrains, those plants not using prechlorination should show the greatest numbers, but this is not the case. Where chlorine is carried entirely through the filter and appears in the effluent, the greatest numbers are found. There is also the possibility that the filters are not entirely responsible for their removal, because at Roxborough long sedimentation may change the life cycle of these organisms so they are in the vegetative state when the chlorine is applied. The writer is not inclined, however, to place much emphasis on this. Neither is he arguing against long sedimentation, for it is the greatest and cheapest asset to any purification process.

The data used for making the presumptive B. coli curves are weighted averages, this being the only way of adjusting the figures to the water consumed by the public or its probable effect upon the population as a whole. The health data are taken directly from the records of the Health Department. It would be of more value if cases were used instead of deaths, for during some seasons the physicians seem to have more cases of diarrhea than others. If cases were used it would be necessary to have the history of each case, but cases are not reportable to the Health Department.

After a careful study of figure 1, it is easy to understand why the 24-hour aërobes may be passed over casually, for ordinarily a water which contains no more lactose fermenting organisms than these 24-hour B. coli would be classified as a well purified water from a bacteriological standpoint and certainly beyond suspicion.

The 48-hour aërobes and anaërobes go through the same cycle of maximum and minimum at almost identical times, showing a maximum in cold months and a minimum during the summer months.

The only two graphs in the health group that show any pronounced cycle of events and might be of any importance are diseases of digestive system, 1 year and over, and diarrhea and enteritis under one year. Certainly the latter could be left out of the discussion because it is very doubtful whether, the water supply of any community has any bearing upon infants' health other than what could be obtained from bathing in the water.

The figures for diseases of digestive system, one year and over, are significant for they show definite maximum and minimum points occurring at times about one half cycle from those of the lactose fermenting organisms and demonstrate what most sanitarians believe to be true, but up until now have failed to prove in a conclusive manner, i.e., a properly purified and chlorinated water can contain lactose fermenting organisms in large numbers other than B. coli and still be safe to drink.

CONCLUSIONS

1. Long, preliminary sedimentation followed by slow sand filtration is the most efficient means for removing the lactose fermenting organisms.

2. The next most efficient arrangement is short sedimentation followed by double filtration, using rapid sand pre-filters and slow sand final filters.

3. The least desirable is a plain rapid sand plant.
4. Prechlorination and post chlorination in conjunction with rapid sand filters are without avail as far as removing these lactose fermenting organisms.
5. Neither yearly climatic conditions nor the mineral characteristics of the water show any relation to the occurrence of these gas forming organisms.
6. The temperature of the water plays a very important rôle in filter efficiencies and this in turn is reflected in the frequency with which these organisms occur in the effluents.
7. Lactose fermenting organisms, to the extent shown in this study, in a properly purified and chlorinated water have no sanitary significance as far as the health of the City is concerned.

The author wishes to express his sincere appreciation to C. T. Hayes, Chief Engineer of the Water Bureau, for the interest shown in this work and also to the members of the laboratory staff.

ABSTRACTS OF WATER WORKS LITERATURE[1]

FRANK HANNAN

Key: American Journal of Public Health 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

The Boiler Water in Cane-Sugar Mills. P. HONIG and J. F. BOGTSTRA. Mededeel. Proefsta. Java-Suikerind. 1930, 77 pp. From Chem. Abst., 24: 6050, November 20, 1930. Boilers at two of largest and newest mills, working at pressure of 19 atmospheres, started to leak and extensive study was made to determine if leakage was due to condition of feed water. Damage to boilers may be due to corrosion or to incrustation. This article deals with corrosion; incrustation will be dealt with later. Survey is given of literature and results of analyses of boiler feed water at several factories in Java. Conclusions are that return water can be used without danger if certain conditions are met. The pH value of boiler water should not be above 10, maximum amount of organic matter should not be more than 2 grams potassium permanganate per liter, and oxygen should be nil. A pH value higher than 10, with excess of organic matter, may cause foaming. Return water as rule is free of oxygen. Special attention should be paid to leaky feed pumps. Soda ash or sodium hydroxide may be added to feed water in case of acidity.—*R. E. Thompson.*

Water Purification in Factory Operation. FRITZ HOYER. Chem.-Tech. Rundschau, 45: 842, 862, 1930. From Chem. Abst., 25: 156, January 10, 1930. Air-cleaned filters are used chiefly for factory and boiler feed water purification and series is so connected that single elements can be cleaned without interrupting filtration. Filters adapted for cleaning water under pressure have thin layers and can be cleaned in from 20 to 40 seconds. Settling basins are applicable for waters contaminated by heavy suspensions which settle readily. These are operated more economically when water enters in slow stream. Coagulating agents such as alum may be added. Process for removal of iron consists of aëration to produce flocculation, contact action, and removal of floc by filtration. Hardness is reduced to zero by filtration through artificial zeolites or Permutit. Preparation and recovery of Permutit after use are discussed. Dissolved gases are removed from boiler feed waters by heating to reduce solubility, or by vacuum treatment in cold.—*R. E. Thompson.*

[1] Vacancies on the abstracting staff occur from time to time. Members desirous of coöperating in this work are earnestly requested to communicate with the chief abstractor, Frank Hannan, 285 Willow Avenue, Toronto 8, Ontario, Canada.

A New Method for Quickly Testing the Corrosion of Different Metals Simultaneously. G. Gollnow. Die Giesserei, 17: 665, 1930. From Chem. Abst., 25: 63, January 10, 1931. Apparatus of Tödt (Chem.-Ztg., 29: 567), manufactured by Ströhlein & Co., Braunschweig, Wolfenbütteler Str. 41, for electrically measuring corrosion is briefly described and directions for its use are given.—*R. E. Thompson.*

Purely Chemical Methods for Prevention of Corrosion of Metals. Jean Cournot and Jean Bary. Rev. metal., 27: 479–85, 1930. From Chem. Abst., 25: 63, January 10, 1931. Brief survey of methods of coating metals, including bronzing of steel and parkerization, giving some results of corrosion tests in salt spray on latter. Mention is made of new process somewhat similar to parkerization invented by Boulanger and giving remarkable protection.—*R. E. Thompson.*

The Nature of Corrosion and Its Measurement. G. Dorfmüller. Deut. Zuckerind., 55: 981–2, 1930. From Chem. Abst., 25: 63, January 10, 1931. Discussion.—*R. E. Thompson.*

Effect of Contamination by Nitrogen on the Structure of Electric Welds. L. W. Schuster. J. Iron Steel Inst. (London), advance copy, September 1930, No. 8, 30 pp. From Chem. Abst., 25: 63, January 10, 1931. Microscopic examination of arc welds made from various rods and in atmospheres of air, carbon dioxide, oxygen, nitrogen, and hydrogen have shown that needles found in welds are caused by nitrogen. Needles never occur in absence of nitrogen. Heat treatment is frequently necessary to develop needles. Typical photomicrographs are shown. Bibliography of 50 references is included. Also in Engineering, 130: 538–40, 1930.—*R. E. Thompson.*

A Study of the Bactericidal Action of Ultra-Violet Light. III. The Adsorption of Ultra-Violet Light by Bacteria. Frederick L. Gates. J. Gen. Physiol., 14: 31–42, 1930; cf. C. A., 24: 2490. From Chem. Abst., 25: 129, January 10, 1931. Conclusion of previous investigators that the shorter the wave length of ultra-violet light the greater the bactericidal action is erroneous. Maximum bactericidal efficiency is reached between 260 and 270 mμ. Reciprocal of this abiotic energy curve suggests specific light absorption by single essential substance in the cell. This substance is probably not uniformly distributed throughout cell protoplasm. Methods are described for determining absorption curve of intact bacterial cells, and curves for *E. coli* are given. Further work is in progress.—*R. E. Thompson.*

Uniform Description of Graded Materials and the Evaluation of Their Fineness. M. Spindel. Tonind.-Ztg., 54: 1385–6, 1401–3, 1930. From Chem. Abst., 25: 155, January 10, 1931. Proposal is made to set up metric fineness modules with sieve openings of 1, 10, 100, 1000, ... 10^6 microns as basis and divide each range into 5 divisions, the logarithm of whose openings shall be 1.0, 1.2, 1.4, 1.6, 1.8, 2.0, which correspond to fineness moduli of gradings of aggregate whose average size corresponds to that sieve opening.—*R. E. Thompson.*

Water Purification with Aluminum Sulfate. W. PRANN. Chem.-Tech. Rundschau, 45: 881, 1930. From Chem. Abst., 25: 156, January 10, 1931. Choice of coagulant requires exact investigation of water if alkalies or iron salts are to be employed. Best coagulant is technical aluminum sulfate, which is strongly hydrolyzed in aqueous solution with percipitation of aluminum hydroxide. Solubility of alum in water between 0° and 100° is given. Amount used should vary between 20 and 80 p.p.m., depending on character of water. Alkali may be added soon, or immediately, after alum. After settling, water is passed through gravel filter.—*R. E. Thompson.*

Purification of Water with Use of Activated Carbon. MILLARD BRANDT (to Darco Corporation). U. S. 1,781,314, November 11, 1930. From Chem. Abst., 25: 158, January 10, 1931. Carbon is disposed in pervious bed of highly activated, firm, electricity-conducting, oxygen-absorbing particles in a container such as iron or steel and container is electrically insulated (as by rubber or bakelite lining) from bed in such a way as to prevent carbon from forming galvanic couples with oxidizable metals when apparatus is in use, thus to make oxygen adsorbed by the carbon available for reaction with impurities in the water. Various details of apparatus are described.—*R. E. Thompson.*

Technology of Malting. V. Influence of the Composition of Steep Water. E. JALOWETZ. Brau- und Malzindustrie, 2: 25–7, 1930. From Chem. Abst., 25: 167, January 10, 1931. Steeping experiments were carried out on same barley with well water and with waters containing lime, gypsum, and lime and gypsum. Results showed that mineral composition of steep water had no effect on constituents and character of malt. Only exception was remarkable increase in color after boiling with hops in malts treated with alkaline water. —*R. E. Thompson.*

Waterproofing of Concrete Structures. H. R. LORDLY. Trans. Soc. Eng. (London) 1929, 55–93. From Chem. Abst., 25: 184, January 10, 1931. Tarry solutions should be applied to surface when warm. A processed artificial gypsum, acting as carrier for tannin, is added to portland cement to make it waterproof. It also acts as catalytic agent to promote hydration of silicates and aluminates. Mixtures are given for cement laid under water, used to stop leaks from inside and for repairing underwater damage to ships.—*R. E. Thompson.*

Preventing the Harmful Action of Gases and Waste Waters Containing Phenols in the Operation of Gas Producers. FELDHAHN. Zentr. Gewerbehyg. Unfallverh., 17: 122–3, 1930; Chimie & industrie, 24: 587. From Chem. Abst., 25: 190, January 10, 1931. Author suggests method of keeping scrubber and cooling waters separate, to prevent pollution of watercourses with phenol. —*R. E. Thompson.*

Classification and Specifications of Siliceous Sands. RALPH TUCK. Econ. Geol., 25: 57–64, 1930. From Chem. Abst., 25: 266, January 20, 1931. Sand is defined as an aggregate of unconsolidated, or loosely coherent, minerals, or

rock fragments, that range in size from $\frac{1}{500}$ to $\frac{1}{8}$ inch. Lack of uniform specifications for sand for varied uses leads to much confusion. Detailed scheme of classification of siliceous sands is given, together with specifications for sand for various uses, including filter sand. Sieve tests of characteristic sands are given.—*R. E. Thompson.*

The Radium in Aquatic Organisms. V. VERNADSKII. Compt. rend., **191**: 10, 421–3, 1930; cf. C. A., **24**: 3706, 5773. From Chem. Abst., **25**: 315, January 20, 1931. Experiments show that during season of maximum flowering of different varieties of *Lemma*, radium concentration of surrounding water is negligible, while that of living plant varies from 1.3×10^{-11} to 2.0×10^{-12} parts of radium per 100 of plant. Decomposition of water by radium ceases, or diminishes, as radium from water is concentrated in the plant.—*R. E. Thompson.*

Biochemical Studies on Endemic Goiter in Hungary on the Basis of the Iodine Deficiency Theory. J. BODNAR and JOHANN STRAUB. Biochem. Z., **227**: 237–44, 1930. From Chem. Abst., **25**: 339, January 20, 1931. In the Bodahegyközség district, 82 percent of school children and 24.6 percent of entire population suffer from endemic goiter. The drinking water of district contains from 0 to 12γ iodine per liter.—*R. E. Thompson.*

Water Supply and Distribution. GÜLICH. Gas- u. Wasserfach, **73**: 961–7, 1930. From Chem. Abst., **25**: 365, January 20, 1931. Modern uses have caused enormous increase in water consumption. State surveys should be made as to available water supplies, water-bearing strata, and geological features of given area to avoid future water famines as far as possible. Surface water supplies previously considered unusable may now be treated in satisfactory manner, but avoidable contamination should be lessened. Several municipalities may well combine their systems for better handling of peak demands and emergencies. Water meters are desirable. The normal (German) water consumption of 80–82 liters per capita, including industrial uses, may increase to 150 liters in hot dry weather due to increased use for cooling, sprinkling, etc. Leakage causes enormous losses, up to from 30 to 40 percent in old systems.—*R. E. Thompson.*

Technical Features of the Old Magdeburg Waterworks on the Elbe. OTTO KOENIG. Gas- u. Wasserfach, **73**: 933–4, 1930. From Chem. Abst., **25**: 366, January 20, 1931. Mechanical equipment is described. Residual chlorine is controlled by OLSZEWSKI-SPERLING apparatus which automatically indicates reaction of treated water with *o*-tolidin and with zinc iodide-starch solution at definite intervals. Aluminum chloride is used as precipitating agent, as it gives quicker and better precipitate than alum, especially when prechlorination is employed. Both rapid sand and slow sand filtration are used. Sufficient active charcoal is added to slow filter to form layer 0.2 millimeter thick on its surface. This layer adsorbs some organic substances, including phenols, etc., and resultant water has satisfactory taste, odor, and color. Methods employed for cleaning filter sand are described.—*R. E. Thompson.*

Hydrion Concentration of Rain and Potable Water. M. C. POTTER. Nature, **126**: 434–5, 1930. From Chem. Abst., **25**: 366, January 20, 1932. The H-ion concentration of rain water in New Milton, England, showed wide variations over period of 1½ years. Rain carried direct from sea by winds was practically neutral, while that from direction of towns, or of long stretches of country, tended to be acid.—*R. E. Thompson.*

Significance of B. Coli in Water. J. KISTER. Tech. Gemeindeblatt, **33**: 219–21, 1930. From Chem. Abst., **25**: 368, January 20, 1931. Review of procedures for identifying *B. coli* in water. *B. coli* tests are of great value in judging quality of water.—*R. E. Thompson.*

Filtration of Chicago Water Supply. LOREN D. GAYTON. J. West. Soc. Eng., **35**: 343–62, 1930. From Chem. Abst., **25**: 366, January 20, 1931. Report of results of 2 years' operation of experimental filtration plant built by city of Chicago to determine whether its public water supply can be made safe and palatable. Among main facts brought out to date are: (1) Lake Michigan water may be made perfectly clear and pure by filtration at cost about the average of that for other cities; (2) water of highest purity is procured; (3) purity of water produced since December, 1928, exceeds that of the most palatable spring water; (4) water containing abundance of microörganisms may be handled without difficulty; (5) treatment of water with high microscopical counts involves no uncertainties; (6) method for complete elimination of taste-producing compounds has been perfected; (7) method for handling highly polluted water has been developed; (8) most suitable method of treatment will effect partial softening; (9) value of the water carried away from experimental plant by the public for drinking purposes exceeds entire operating cost of experimental plant. The plant and special apparatus are described and numerous tables and charts are given.—*R. E. Thompson.*

Purifying Water with Activated Carbon. ROY L. HILL (to Darco Corporation). U. S. 1,782,850, November 25. From Chem. Abst., **25**: 369, January 20, 1931. Natural water is mixed with very small proportion of activated carbon, and water containing the carbon in suspension is then given slow rotational velocity, which may be about one or two turns about axis of a cylindrical tank, to produce accelerated settling of carbon. Apparatus is described. Cf. C. A., **25**: 158.—*R. E. Thompson.*

The Use of Barium Aluminate in Water Softening. ANTONY SETON. Eng. and Boiler House Rev., **44**: 54–6, 1930. From Chem. Abst., **25**: 367, January 20, 1931. Previous work (C. A., **24**: 1687) has shown that combination of properties of barium and aluminum salts for water softening is of value in that precipitation of sulfate as well as of calcium and magnesium can be accomplished by it. This paper describes chemical properties of barium aluminate in such procedure and suggests possibility of employing it as substitute for sodium aluminate. Commercial barium aluminate can be obtained in powdered form which is from 38 to 40 percent water soluble, approximate composition being $11BaO \cdot 8Al_2O_3$. Laboratory studies indicate that from 1.5 to 2

times the theoretical amount of aluminate is required for precipitation of calcium sulfate, calcium bicarbonate, magnesium sulfate, and magnesium chloride, precipitation being from 80 to 95 percent complete. Mixtures of calcium bicarbonate and calcium sulfate were precipitated by the amount necessary for the bicarbonate alone, thereby reducing ratio in practical water softening to theoretical value. With mixtures of magnesium salts, three-quarters of theoretical amount was adequate. Study is to be continued under industrial conditions.—*R. E. Thompson.*

Computation of Mineral Water Analysis. L. Fresenius and O. Fuchs. Z. anal. Chem., **82**: 226–34, 1930. From Chem. Abst., **25**: 366, January 20, 1931. Formulas proposed by L. Grünhut, which are given in König's Handbuch, are replaced by new ones which are considerably simpler. H-ion concentration is used in place of certain empirical factors proposed by Grünhut. Table is given showing effect of temperature upon ionization constants of weak acids likely to be present and this permits approximately correct calculation of condition of weak acids at temperature of the mineral-water spring.—*R. E. Thompson.*

Two-Stage Tanks for Waste Containing Phenol in Hattingen. Franz Fries. Tech. Gemeindeblatt, **33**: 206–10, 1930. From Chem. Abst., **25**: 369, January 20, 1931. Description of plant in which waste containing 45.4 p.p.m. phenol was so well purified that effluent contained only traces of phenol.—*R. E. Thompson.*

Action of Purified Feed Water on the Boiler Equipment of the Thermo-Technical Institute. A. N. Rumyantzev. Izvestiya Teplo-Tekh. Inst. (Trans. Thermo-Tech. Inst. Russia), 1930, 1, 12–21. From Chem. Abst., **25**: 368, January 20, 1931. Soda-lime treatment of feed water assures satisfactory performance of boilers. Oxygen present in condensate which is recycled is very detrimental to boiler equipment. Method for collecting samples for oxygen determination is described.—*R. E. Thompson.*

Predetermination of Soil Corrosion. J. F. Putnam. Oil and Gas J., **29**: 26, 158, 159, 187, 1930. From Chem. Abst., **25**: 370, January 20, 1931. Simple ammeter-voltmeter test can be used to predict corrosiveness of soil. Method gives close correlation with corrosion experience.—*R. E. Thompson.*

Evaluation of Active Carbons. E. Berl and W. Herbert. Z. angew. Chem., **43**: 904–8, 1930. From Chem. Abst., **25**: 383, January 20, 1931. Together with other methods, phenol adsorption and methylene blue tests are investigated and criticized. Modification of latter by altering amount of methylene blue to give final concentration of 1 gram per liter is advocated for greater accuracy. Duboscq colorimeter may give results 15 percent in error with comparison columns varying in depth by 2 to 1.—*R. E. Thompson.*

Determination of Phenols (Acid Oils) in Gas- and Low-Temperature Carbonation Liquors. E. Kres. Brennstoff-Chem., **11**: 369–71, 1930. From

Chem. Abst., **25**: 396, January 20, 1931. Comparative determinations were made on several liquors. Previous methods, which are discussed briefly, were used and also one developed by author. Latter consists of removing the phenols by distillation from the filtered liquor to which has been added copper sulfate solution and dilute sulfuric acid, and completing the estimation colorimetrically or by bromination. Modifications for various liquors are described. —*R. E. Thompson.*

Bituminous Pipe Coatings. RUSSEL R. BRANDT. Metal Cleaning and Finishing, **2**: 799–802, 1930. From Chem. Abst., **25**: 408, January 20, 1931. Coal tar pitch for use as protective coating should be refined by distillation to remove light oils. This operation will render the tar more resistant than asphalt, although it is affected by temperature changes. This defect may be overcome to some extent by more thorough refining and also by careful blending with drying oils or with other pitches. Several brands of bituminous coatings on market have coal tar base and show real merit. Coal tar primer coats seem to give satisfactory results if followed by proper finish. Care must be exercised in applying cold-cut primer of this type as solvents will usually flash at or below room temperature. Furthermore, air bubbles are easily entrapped, resulting in porous coatings. Natural asphalts, as taken from lakes, differ considerably in character and do not, even after refining, possess the desired characteristics. They must be blended, usually with other asphalts, to secure desired consistency and temperature range. Petroleum pitch has the properties of an asphalt. The manufacture may be regulated so as to give product meeting the required specifications. Two or more asphalts of this type may be blended, or a natural asphalt incorporated, to give certain desired characteristics. Dipping is ordinarily employed in coating pipes with bituminous materials other than primers. Various methods are described in detail. In manufacture of emulsions of asphalt and water, lately appearing on market, the asphalt is broken up into particles with diameter of $\frac{1}{5000}$ to $\frac{1}{10000}$ inch in presence of water and of small percentage of inert mineral colloid such as clay. This material has consistency of cup grease, but may be thinned with water. It may be applied by brushing, or, preferably, by spraying. When the water evaporates, after application, the minute particles of asphalt coalesce and give uniform film of pure asphalt.—*R. E. Thompson.*

Recovery of Phenol from Coke-Oven Gas Liquor in Relation to the Best-Known Processes of By-Product Recovery. H. WIEGMANN. Brennstoff-Chem., **11**: 285–8, 304–6, 1930. From Chem. Abst., **25**: 398, January 20, 1931. Schematic diagrams are given to indicate incorporation of phenol recovery units in direct, semi-direct, and indirect by-product recovery systems. Flow capacities are given to show possible recoveries.—*R. E. Thompson.*

Tastes and Odors Due to Algae. SAMUEL E. KILLAM. Water Works Eng., **85**: 18, 1052, September 7, 1932. Early in 1932, Spot Pond, a natural pond improved and enlarged with dams and dikes, the storage reservoir of Boston Metropolitan District, had a very bad growth of algae. All mud deposits were covered with about 12 inches of sand and gravel: practically all natural drain-

age of watershed is by-passed: capacity of reservoir is 1,800 million gallons. Inlet and outlet chambers are of masonry, each with two sluice gates at different depths. Water enters low-service mains direct and is pumped to high-service mains. In September 1931, there were about 7500 *Synura* per cc. These disappeared in October and *Uroglenopsis* followed with count varying from 1000 to 3500 per cc. Trouble was further increased by luxuriant growths of *Dinobryon* and *Synura* in latter part of year. As pond was frozen, no preventative measures could be applied. Tastes and odors were partially controlled by treating with ammonia shortly before chlorination. Up to 9.4 pounds of chlorine and 2.0 pounds of ammonia were added per million gallons. Tastes and odors largely disappeared, except in dead ends, where they appeared to increase. As soon as ice broke up, copper sulphate was applied to reservoir by dragging in sacks through water at rate of 2.6 pounds per million gallons. Ammonia treatment was continued for 5 more days. Chlorine treatment has been maintained at about 3.0 pounds per million gallons. Trouble has cleared up.—*Lewis V. Carpenter.*

Obligation to Supply Water. Leo T. Parker. Water Works Eng., **85**: 18, 1063, September 7, 1932. Water consumers may not compel municipal, or private undertaking to supply water, or extend its mains, unless reasonable income will result. Under certain circumstances, water company may compel consumers to guarantee yearly income dependent upon expense, or investment, in making extension. Franchise for supplying water in county, or township, is not conclusive that water company agrees to supply water to all persons within designated area. Consumer is not liable either to municipality, or to private water company, for payment for water not utilized and not contracted for. Water service cannot be cut off to force payment of independent collateral liability. If municipality, or state, condemns, or otherwise seizes, private property for public purposes, it must be shown that right to do so is given by state statutes. Also, if property owner is not satisfied, he may file suit and request Court to render judgment of valuation. Each riparian owner is entitled to have stream pass over his land without unreasonable decrease in quantity of water as result of use thereof by up-stream owners. Municipality, or water company, is liable in damages for injury negligently inflicted by its officials or employees.—*Lewis V. Carpenter.*

Tests Made to Prolong Life of Paint on New Water Tanks. D. W. Johnson. Water Works Eng., **85**: 17, 1010, August 24, 1932. One of main objections of neighbouring property owners to storage tanks is their undesirable appearance, especially as regards paint generally used. It is necessary to choose paint which not only protects tank, but also looks well. Three different types of primer, Pittsburgh red lead, commercial red lead primer, and special chromimum primer, were applied, side by side, to same tank and each covered with two coats of aluminum paint. After one year, no differences could be detected. All appeared in good condition. It requires about three years for all mill scale to loosen. Two coats of aluminum paint with no primer coat failed in six months. Steel must be thoroughly cleaned before paint is applied.—*Lewis V. Carpenter.*

Injury to Trespassers. Leo T. Parker. Water Works Eng., **85:** 17, 1008, August 24, 1932. A young child is not guilty of legal trespass and can collect damages caused by negligence of employees. Municipality is bound only to exercise ordinary care to maintain its premises in safe condition for persons who are expressly, or impliedly, invited on to property owned by city. City owes to licensee no duty as to condition of premises, save that official should not knowingly let him come upon hidden peril, or hazard, or wilfully cause him harm, while to invitee, official is under obligation to render reasonable security for purposes of invitation. Person on premises by invitation, express or implied, is termed invitee, whereas one present merely by permission, or toleration, is termed licensee. It is duty of municipal corporation to protect public from dangers near, or in close proximity to, sidewalks. Municipality is liable in damages for injuries resulting from machinery left in public street, if it is proved that injury did not result from negligence on part of injured person. Leaving unlighted machinery on highway is negligence. Municipalities are not liable in damages for injury sustained by pedestrian on private property which pedestrians are not expected to utilize as public way.—*Lewis V. Carpenter.*

Effect of Chlorine Treatment on the Acidity of a Water. Anon. Water and Water Eng., **34:** 408, 433, September 20, 1932. Hydrochloric acid is produced when chlorine reacts with organic matter, or with de-chlorinating agents, such as activated carbon, sulphites, etc., but in quantities so insignificant in comparison with alkalinity usually present that pH and corrosiveness remain practically unaffected except in very soft waters from mountain reservoirs. Determination of bicarbonate hardness is recommended before chlorination is adopted.—*W. G. Carey.*

Water Softening with Trisodium Phosphate Combined with Other Chemicals. F. Kroemer. Chemiker Zeitung, **56:** 411–412, 1932. Trisodium phosphate being expensive, economy is effected by pre-treatment with lime and by returning portion of blow-down to the feed. Phosphate treatment may be combined with lime-soda-ash softening, which latter must not be carried too far, else advantage of phosphate is lost. Phosphate may be added in special vessel with filter, or in feed-water heater, and it may be advisable to return condensate through phosphate treatment vessel, to eliminate oil.—*W. G. Carey.*

A Waterborne Epidemic of Typhoid Fever. J. Ritchie and E. Armstrong. Jour. Hygiene, **32:** 417–430, July 1932. Outbreak occurred in Ecclefechan, Scotland, in 1930. Water supply gravitates from springs and is not filtered. Evidence incriminating water was: (1) only residents in water area were stricken; (2) case incidence, 55 per 1000, indicates water, particularly as district is rural and mass infection hardly possible; (3) at least 19 separate milk supplies were used by patients; (4) age and sex incidence indicate water; (5) ice-cream and foodstuffs are ruled out; (6) no resident working elsewhere was attacked; whereas (7) three men living elsewhere, but working in district, two of whom were large water consumers, contracted disease; (8) hot weather caused abnormal water drinking; (9) patients in sanatorium with separate

water supply all escaped infection. Typhoid carrier was discovered in water-collecting area, and it was found that surface water and spring water were mingling freely. Highest peak in rainfall was charted one week before highest peak of typhoid incidence. Storage tank was emptied and refilled with strongly chlorinated water and pipe line overhauled.—*W. G. Carey.*

Chemistry of Boiler Water. H. E. Jones. Fuel Economy Review, 2: 75-86, 1932. Dense scale formation is prevented in low-pressure boilers by preliminary lime-soda-ash softening, followed if needful by more soda ash to maintain correct sulphate: carbonate ratio. At high pressure (250 pounds), water should be conditioned by phosphate, to prevent embrittlement, and, for still higher pressures, deaërated distilled water should be used, treated with sodium hydroxide to prevent corrosion and also with sodium sulphate and phosphate to prevent embrittlement.—*W. G. Carey.*

The University of Illinois Water Supply. I. L. Wissmiller. The Technograph, 47: 2, 5-11, November 1932. Water obtained from underground sources is supplied to student body of 11,000. Iron removal plant includes aëration, filtration, and chlorination. Separate distribution system for fire protection.—*H. E. Babbitt.*

Some Aspects of Water Conservation. R. A. Sutherland. Trans. Am. Soc. C. E., 96: 157-229, 1932. Formulas are developed for studying merits of various storage and dam sites, which have been tested in practice and found to give reasonable results. Methods for studying relative economies of different types of dams are given. Economic limits of specific capacity, or water stored per cubic yard of masonry in dam, are discussed by means of examples in practice. The future holds great promise, as probably only 10 percent of possible development has been completed. Common errors in investigation and development of water conservation have been: (1) use of insufficient data; (2) inadequate knowledge of relationship between rainfall and run-off; (3) under-estimation of flood flows and insufficient spillway provision; (4) insufficient geological examination; (5) incorrect or faulty dam design; (6) uneconomical choice of dam site and dam type. Longitudinal profile of most rivers approaches a parabola. This knowledge aids in selection of dam and reservoir site. Reservoir capacity, w, can be expressed as $w = C h^m$, where C is a coefficient dependent on w and h, h is depth of water at dam, and m, an exponent dependent on w, C and h. Values for constant and exponent are given for practical conditions: also a nomograph for solution of the equation. Submerged area, s, of reservoir can be expressed as $s = mCh^{m-1}$ in which C, m, and h are as above. Tables and diagrams of values and for solution are presented. Factors affecting desired type of dam are discussed. It is shown that for existing dams, $l = Dh^v$ in which l = width of dam site at any height h, D is a coefficient depending on l and h^v, h is the height of the dam site to any elevation, and v, an exponent. Equations for the volumes of dams of different types are given, together with nomographic charts for their solutions, and comparisons with existing dams. For every installation involving storage there exists a size of storage which gives the most economical result in terms of cost per

second-foot of regulated outflow. Graphical solutions are given. Formulas and charts for determination of specific capacity of gravity, arch, and constant-angle arch dams, with comparisons of existing dams, and method of comparing cost of storage at different dams are given. Method for comparing dam sites and reservoirs, involving 15 steps, is given in discussion. Geologic "life" of a stream is outlined and its effect on reservoirs and dams is studied mathematically.—*H. E. Babbitt.*

Engineering Uses for Geophysics: An Aid in Locating Water. S. F. KELLY. Civil Engineering, 2: 10, 629. October, 1932. Seismic prospecting relies on a series of portable seismographs to record earth vibrations that have been set in motion by exploding a charge of dynamite. Electric methods depend on observation of differences in electrical resistivity shown by various rocks and soils. Gravitational exploration utilizes a special torsion balance to measure the warp produced in field of gravity by masses of rock of greater or less density than their surroundings. Magnetic instruments have been used with success by State Geological Survey of Missouri and electrical methods by State Geological Survey of Illinois to aid in determining subsurface geological formations for purpose of finding water. Magnetic observations in themselves do not show location of water: results must be interpreted by a competent geologist. An electrical survey successfully traced location of a water-bearing formation in construction of tunnel in British Columbia. Use of a Megger ground tester successfully located water-bearing gravel in Illinois.—*H. E. Babbitt.*

Control of Water Growths. S. G. PORTER. Civil Engineering, 2: 10, 651, October, 1932. Brief description of attempts to remove weeds from storage reservoir and diversion canal. Poisoning and water discoloration proved ineffective. Only cutting was successful.—*H. E. Babbitt.*

Systematic Sequences in Annual Stream Flow. A. STREIFF. Civil Engineering, 2: 11, 690, November, 1932. Method of probability in prediction of stream flow has been superseded. Average values of precipitation records may furnish satisfactory results for short-time predictions, but they cannot be extended far into the future because meteorology deals with momentary values while hydrology deals with cumulative quantities. Changes in rainfall are amplified in run-off. In Michigan, 30 percent increase in rainfall doubles the run-off. Regarding stream flow as a systematic sequence implies possibility of continuing the sequence into the future, qualitatively and quantitatively, for estimation of future stream-flow records. The HORTON cycle has recurred ten times since 1875 and five times since the publication of its discovery: with its use and with WOLF numbers predictions can be made with precision. Systematic nature of flow of rivers in southern Michigan has made possible quantitative predictions of stream flows two years in advance, with errors as low as 1.3 percent and no higher than 5.4 percent. Because of similarity between conditions in Michigan and along the Dneiper River in Russia, method is applicable there. Current views on fortuity of annual stream flow need revision. Systematic sequences are strongly evident on the great continental plains, but are less regular in mountainous and coastal regions. But even in

those areas, nature, though infinitely complicated, will permit the separation of systematic sequences from the tangled mass of available data. In time it will be possible to predict the characteristic trends of stream flow with an accuracy not possible at present.—*H. E. Babbitt.*

Nashville Water Works, Pumping Station, Filtration Plant, and Recent Installations. R. L. LAWRENCE. Southern City, October, 1932. System supplies approximately 180,000 people with an average of approximately 19.5 million gallons daily. Water is taken from Cumberland River at point where watershed area is about 12,000 square miles. The George Ryer Pumping Station has total capacity of 50 m.g.d. for high service and 20 m.g.d. for low service. Rapid sand filter plant has capacity of 42 m.g.d. Data on pumping station performance are given in detail together with modicum of information on design and cost of filter plant.—*H. E. Babbitt.*

Two Views on Licensing Well Drillers. G. E. NELSON and R. B. HARTMAN. The Illinois Well Driller, 2: 4, 1, October, 1932. Bill to license well-drillers was presented to legislature of Wisconsin at their last session and lost by a few votes, due mostly to fact that drillers of state were uninterested. Danger of licensing is that it might lead well-drillers into bureaucracy, of which we have too much already. This may be far-fetched; but it plainly shows pitfalls which lie in path of license law. Arguments favoring adoption of license law are generally based upon principle of protection of health of public.—*H. E. Babbitt.*

Cost of Pumping Water from Deep Wells. C. F. HARRIS. The Illinois Well Driller, 2: 4, 2, October, 1932. Comparison is made between charges for water generally made by municipal water works and cost of power for pumping from deep wells.—*H. E. Babbitt.*

Recent Developments in Storage Tanks for Liquids and Gases. H. C. BOARDMAN. Bulletin Associated State Engineering Societies, 7: 2, 30, April, 1932. Welding is rapidly becoming standard practice for joining bottom plates. For riveted construction, an angle connects the shell and bottom. Now the shell and bottom are welded together. In view of the unknown high stresses which occur in tanks, design is bold; but few failures are on record. There are indications that butt welds will grow in favor, although lap welds are now more common. Economic height for all storage tanks is about 40 feet. Large, field-erected bullets and blimps are comparatively recent developments. For all-welded construction, spheres are more economical than blimps. Determination of economical proportions of a vertical blimp involves many variables. The "Hortonspheroid," a patented shape, resembles drop of water on hot stove. Methods and equations for analyzing stresses in this form of tank are given. Radial cone tank is most recent development in elevated tank field: tank bottom is formed of as many radial troughs, each a portion of a right cone, as there are radial girders. Recent radial cone tanks of large capacities in various cities are described. The ellipsoidal-bottomed tank puts an indeterminate load on riser pipe: radial-cone bottom puts definite load on riser pipe. Two schools of the "tank beautiful" are discussed.—*H. E. Babbitt.*

The Modern Trend in Water Treatment and its Relation to Engineering Design. C. H. SPAULDING. Bulletin Associated State Engineering Societies, 7: 2, 83, April, 1932. Trend towards more complete purification, with production of safe, clean, soft, odorless, and taste-free water in stable equilibrium, so as to be neither corrosive nor scale-forming, is pointed out. This is accomplished by improvements in pre-sedimentation, mechanical agitation rather than baffled mixing, use of clarifiers, reduction of load on filters with increased rates of filtration, increased rates of washing, wide-spread adoption of softening, and removal of tastes and odors through chlorination and activated carbon.—*H. E. Babbitt.*

Water Supply of Delaware County Menaced. H. M. FREEBURN. Civil Engineering, 2: 12, 756, December, 1932. Increasing pollution of Delaware and other rivers, due to industrial wastes, has resulted in objectionable odors and tastes which are placing heavy load on water purification plants. Problem is particularly difficult of solution at Chester and vicinity. Experiments have resulted in conclusion that best way to meet condition is by extension of existing water purification plant together with construction of sewers and sewage treatment plants. It seems obvious that Delaware River at Chester will eventually become unfit for use as a public water supply, as it has almost reached that state already. It will be necessary to abandon most of present sources of water supply in the county and to develop the upper Delaware and Lehigh Rivers.—*H. E. Babbitt.*

New Jersey Ground Water Supply Abundant. H. T. CRITCHLOW. Civil Engineering, 2: 12, 774, December, 1932. Character of rocks and their structural relations vary in the four principal topographic regions of state, Appalachian Valley, Highlands, Piedmont Plain, and Coastal Plain. In general, ground water is not so plentiful in northern as in southern part of state. In Appalachian Valley, rocks do not carry large volume of ground water. Same conditions prevail in Highlands. In Piedmont Plain, no well-defined water-bearing beds are known to exist, but strata carry more water than those of Appalachian Valley or of Highlands. Flowing wells of great volume have been obtained at a few places in Piedmont belt. Coastal Plain, constituting more than three-fifths of area of state, presents striking contrast to preceding three divisions. Many of sand and gravel beds in Coastal Plain are so porous as to have great capacity for storing water and so interlaminated with impervious beds of clay and marl that vast quantities of water are held under such pressure as to furnish abundant artesian flow. Records of wells have been collected for many years by State Geological Survey. Numerous bulletins have been issued summarizing the data and giving general conclusions as to safe yield.—*H. E. Babbitt.*

Some Ground Water Problems in the Southeastern States. DAVID G. THOMPSON. Paper presented before Southeastern Section of the American Water Works Association. In South Carolina, Georgia, Alabama and Mississippi there is a total of 560 underground, as against 133 surface supplies. The total consumption per day from the surface is greater than that from the

ground sources, due to the fact that the supply for large cities is obtained from surface sources. It is estimated that in each of these states the annual cost to consumers of water from underground sources is between $1,000,000 and $2,000,000. With a few exceptions the entire State of Mississippi lies within the Coastal Plain province where ground water supplies are easily obtained and all but 6 of the public supplies are obtained from wells or springs. Georgia includes parts of five geologic provinces, the Coastal Plain, Piedmont, Blue Ridge, Valley and Ridge, and the Appalachian. The supplies of towns and cities of the Coastal Plain are derived from ground water. In other provinces where conditions are less favorable for obtaining ground water a larger number of systems use surface water. Although detailed information is not available in regard to the distribution of systems using ground water and surface water in Alabama and South Carolina somewhat similar conditions may be expected. On the Coastal Plain water from some formations contains much iron. Some waters also contain hydrogen sulphide or carbon dioxide in sufficient quantity to be troublesome.—*A. W. Blohm.*

The Purification of an Indian Upland Water. The Jamshedpur Water Works. F. C. Temple and V. N. Sarangdhar. Paper presented at the Annual Meeting of The Institution of Engineers (India), at Lucknow, January 1932. The water supply of the town of Jamshedpur, of the Tata Iron and Steel Works, and of the Associated Companies, is derived from the river Subarnarekha after its junction with its tributary the Khorkai. The intake is located below the point of natural drainage of a large part of the town. It is stated that it is but little more difficult to purify the water when the river flow has stopped and only the town drainage is flowing into the reservoir, than when a storm first washes the dirt accumulated through months of dry weather off the catchment area of some 4200 square miles. The location of the intake was made before the town had grown to its present size and now it is cheaper to protect the river by the construction of intercepting sewers and pumping stations. Eventually none of the dry weather flow of sewage will reach the river untreated and the first overflow of storm water from the sewers will reach the river after the removal of floating and settleable solids. For the steel works, the water is pumped into the "Upper Cooling Tank: an artificial sheet of water with a surface area of some 57 acres, and a capacity of about 200 million gallons. This lake overflows into the Lower Cooling Tank which has a surface area of some 120 acres, and a capacity of about 800 million gallons." Until 1923 water for boilers and for drinking in the steel works and for domestic use in the town was pumped out of the Upper Cooling Tank to slow sand filters, from which it was pumped to the distribution system. The town water works started in 1923 was designed for an ultimate capacity of 15 m.g.d. and the first installation was for 2½ m.g.d. The scheme as outlined called for the construction of 12 units to have a 1¼ m.g.d. capacity each, and each consisting of a settling tank to give a six day settling period, a reaction tank and a pair of mechanical gravity filters, followed by chlorination. The six day settling period was decided upon to give a 20 percent margin of safety over the 5 day maximum period of settling which had been found necessary to bring about natural bacteriological improvement of the water. During the eight years that the plant has been in

operation there have been many changes in detail. Trouble began when the monsoon set in. 900 parts of silt per 100,000 or 40 tons per million gallons is common and on occasions has measured 2000 parts or 90 tons. To produce a satisfactory floc required 7 grains per gallon of alum and the reaction tanks were relieved of their silt two or three times a day. pH control was started and by reducing it with sulphuric acid it was found that 1.0 grain of alum was satisfactory in removing 90 percent of the silt in the settling tanks, the remainder being easily handled in reaction tanks and filters. Soda ash is used to raise the pH after filtration. Tables and charts showing analyses of water together with plans of the waterworks, etc. are given.—*A. W. Blohm.*

Salamanders and Water Hygiene. WILLIAM G. HASSLER. Natural History, 32: 3, 303, 1932. Recently, salamanders, lizard-like amphibians, have been under suspicion as a source of colon bacillus in water supplies. These creatures occur, often in large numbers, in springs and streams throughout the country. A study of their effect on the water analyses was started about a year ago by the Cattaraugus County Department of Health in western New York State. One hundred salamanders were collected from different springs in the County, placed in sterilized cans, and taken to the County laboratory where they were autopsied and bacteriological examinations made of portions of their gastro-intestinal tracts. A small percentage were found to contain typical colon bacilli, when little or no food was found in the alimentary tracts. Additional tests made on the large purple salamanders indicated how they might infect a spring. They showed that over a period of 122 days one salamander excreted a sufficient number of colon bacilli per day to contaminate 237 gallons of water heavily enough to be considered dangerous on every test. It is believed that they act as reservoirs or incubators and, having once been infected with colon bacillus, continue to excrete them as long as there is food in the salamander's stomach or intestines to supply nourishment to the bacteria. During the year approximately 1400 salamanders, 80 frogs and toads, and 120 snakes were collected in the County.—*A. W. Blohm.*

Welding in Steel Structural Work-British Practice. JAMES CALDWELL. Paper presented at Paris Congress of International Association for Bridge and Structural Engineering, May 25-29, 1932. This paper on the British practice of structural steel welding together with summaries of the practice in Australia, New Zealand and Canada may be obtained from Mr. Caldwell at 14-16 Cockspur Street, London, S. W. 1.—*A. W. Blohm.*

California Typhoid Fever Rate Lowest in History. Weekly Bulletin, California State Dept. of Public Health, 9: 10, 37, April 12, 1930. With a record of but 95 typhoid deaths in California during 1929, the low rate of 2.3 per hundred thousand population was reached, continuing a downward trend which has been steadily consistent except for slight increases in the years 1917 and 1924.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

Division of Sanitary Engineering, Ohio Department of Health Report for 1929—Thirty-First Annual Report 1915-1929, 286. The principal activities of

the Division of Sanitary Engineering for the year 1929 are briefly reviewed. Special features of the activities mentioned include the Great Lakes Division case, disapproval of fine screens for treatment of Toledo sewage and contesting by Bucyrus of a Department order for sewage treatment to correct nuisance conditions in Sandusky River. Appendices summarize detailed activities, water supply and sewage improvements completed and under way during the year 1929.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abst.*).

Municipal Guildford. J. W. Hipwood. Surveyor, 79: 2045, 397, April 3, 1931. Guildford has a present area of 3,199 acres, a population (1921) of 24,926, and a taxable value of £289,655. The present tax rate is 9s. 7d. per £ (about 48 percent). The present water supply is derived from two deep wells which contribute about one m.g.p.d. of safe water. Plans are completed for additional water works and reservoir capacity which will assure ample supply for the future. A full description of the new works is given. The city has one swimming pool which makes use of pressure filters to keep the water clean.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abst.*).

Some Data on Typhoid Carriers in New York. Municipal Sanitation, 1: 11, 628, November 1930. This comment on a bulletin of New York State Health Department points out twenty-seven chronic typhoid carriers discovered during the year 1929 which, exclusive of New York City, brings the total of listed carriers to two-hundred forty. Eighty-six cases of fever were traced to these twenty-seven carriers. Twenty-two of carriers show history previous attack of typhoid fever, in one instance fifty-one years prior to discovery. Details of each case are given.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abst.*).

Sanitation and Sanitary Engineering. Public Health in Cattaraugus County, Seventh Annual Report year ending December 31, 1929, Olean, New York, 78. The Cattaraugus County Health Department organized, in February, 1929, a bureau of sanitary engineering in charge of a trained engineer. The Bureau of sanitation is engaged in the supervision of water, milk and food supplies, and of sewage disposal and general sanitary conditions throughout the county. By the end of 1929 there were thirteen public water supplies with satisfactory protection among the twenty supplying communities in the county, in contrast to six at the beginning of the previous year. A summary is given of the various water supplies in the county and the work done on each supply. Points of special interest are: an outbreak of enteritis in the village of Gowanda caused by gross pollution of the springs and reservoir with farm fertilizer during a period of extreme run-off, the fertilizer had been spread out on frozen ground above the springs; water supplying the village of Portville was suspected of showing contamination due to salamanders present in the supply; inspection of many rural supplies and analyses of 290 samples of water collected from dairy farms and other private sources in the county showed only 38 percent of the samples negative for B. coli in 10 c.c. portions; work on cross connections has succeeded in having conditions remedied in every case found. About 90 percent of the population of incorporated communities receive satisfactory water.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abst.*).

Report of Bureau of Sanitary Engineering—Annual Report 1930. Wisconsin State Board of Health. This report outlines the activities of the Bureau in some detail for the period January 1, 1930, to January 1, 1931. There is appended to this report a table listing public water and sewerage systems. This table shows a population of 1930, ownership of water supply, source of supply and purification if any. The above table lists 293 municipalities of communities with public water supplies, 32 of which secure their supply from surface sources. For the year 1930 it is anticipated that the typhoid death rate will be about 0.9 per 100,000—the 1929 death rate was 1.4 per 100,000.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abst.*).

Annual Report of Division of Sanitation, New York State Department of Health 1929. The force of the Division of Sanitation made 423 investigations of public water supplies. The activities of the Division were connected primarily with investigations of public water supplies, milk pasteurizing plants and the review of plans for sewerage systems and sewage treatment plants submitted for approval. The Division is conducting an intensive campaign for improvements in the technical control of water purification and sewage treatment plants, and a number of laboratories have been installed at these plants as the result of this activity.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abst.*).

Pollution of Reservoirs by Gulls and Other Birds. G. C. Houser. New England Water Works Assoc., **45**: 1, 15, March, 1931. The pollution of reservoirs by sea gulls and other birds has been recorded at various points in the United States and in Canada, Great Britain and Central America. In England, about three years ago, B. A. Adams isolated the typhoid bacillus from gulls excreta collected in the vicinity of a town where typhoid epidemics had occurred. The author of this article believes it should be made lawful to shoot gulls in order to prevent large flocks of these birds from lingering in the vicinity of water supply reservoirs.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abst.*).

Disinfection of the Wanaque Aqueduct. Attmore E. Griffin. New England Water Works Assoc., **45**: 1, 1, March, 1931. In brief, this paper is an account of the successful use of the continuous displacement method for disinfecting pipe lines and aqueducts, a method which is believed to be more convenient and safer than the method of filling and emptying frequently employed. The steel pipe when completed was clean. The Wanaque aqueduct is approximately 20½ mi. long and is divided into a number of sections of 84 in. and 74 in. diameters. Two manually operated chlorinators, each capable of delivering 4 p.p.m. of chlorine to 10 m.g.d. of water, were installed in the upper gate house at Raymond Dam where the aqueduct begins. The quality of the water during the whole operation was most favorable to chlorination and the results were good.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abst.*).

Municipal Engineering in 1929. Surveyor, **77**: 1984, 105, January 31, 1930. Water supply deals with the effect of increasing sewage and industrial waste pollution of streams often necessitating the use of distant, sometimes inade-

quate, upland sources; the design and operation of new works; the location and disinfection of new distribution mains; the ownership of service pipes; the progress of water treatment and methods for the purification of swimming pool water.—*A. W. Blohm (Courtesy U. S. P. H. Abst.)*.

Treatment of Cape Coastal Water Supplies. E. H. Croghan. Surveyor, 79: 2053, 588, May 29, 1931. This article is an abstract of a paper presented at the annual meeting of the South African District of the institution of Municipal and County Engineers held at Capetown, and discusses the subject on general lines. It has been shown that practically complete destruction of typhoid bacteria occurs with five weeks storage at 32°F. and with two weeks storage at 64.4°F. Similar results have been obtained with the cholera germ. The greatest reduction of bacteria takes place in the first week of storage. The Cape Coastal waters generally require no treatment or sand filtration alone. Capetown supply is stored and chlorinated, is clear and bright but has a brown color, is acid and very soft. Studies have shown that the color removal with alumina ferric and filtration intensifies the corrosive action, and that the natural coloring matter forms a protective coating on the lead service pipes.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.)*.

The Struggle Against Drought. L. Chaptal. La Nature, No. 2893, 449-454, November 15, 1932. Two thousand years ago, Theodosia, in the Crimea, condensed from atmosphere upwards of 140,000 gallons daily of water by means of 13 large heaps of stone. During day time temperature in interior of these heaps was so much lower than that outside, that dew was deposited; at night, when temperature outside was lower than in interior, no action went on. An "aërial condenser" on this principle was built in 1929 at Bel-Air, near Montpellier, France. Non-calcareous stones about 5 to 10 cm. in maximum dimension were piled into pyramidal heap 3 m. square at base and 2.50 m. high. Exterior surfaces were faced with concrete, and whole structure rested on concrete base sloping to outlet in center. Adjustable ventilating inlets were provided around both top and bottom. From April to October, 1930, this small condenser extracted about 17 gallons of water from atmosphere; maximum daily yield was about 5 pints. Under less favourable weather conditions in 1931, total yield was about 8 gallons. Author gives following rules for successful operation: (1) ventilation must be adjustable and must effect frequent changes of air in interior; (2) only gentle currents of air are permissible in interior; (3) maintain low average temperature in interior by preventing heat gain during day, and encouraging heat loss at night. Recent improvements include (1) special porous tile in place of stone, (2) radiating fins on exterior, and (3) more thorough insulation.—*R. DeL. French*.

Sea Ice as a Source of Water Supply for Boilers. I. S. Raubine. Sotsial Rekonstr. Rybn. Khz., pp. 61-65, November-December, 1931. Some seaports in winter lack water for boiler supply, seawater being useless for this purpose. Use might possibly be made of abundant ice in bays, which is pure enough, being nearly free from mineral salts and better, therefore, than ordinary water. Conditions of formation of ice are important; it should be uniform

in character; best quality comes from areas where sea is not perfectly calm.—*R. DeL. French.*

Detection of Traces of Aluminum Hydroxide in Water Clarified with Aluminum Sulfate. L. Gizolme. Ann. Fals. Fraudes, **14**: 587–589. October, 1931. Addition of few drops of alizarine (sodium sulphonate) to raw water gives violet tint, due to calcium salts, which masks red-brown colour produced by traces of aluminum: violet tint disappears on addition of few drops of acetic acid. In distinctly acid waters, method fails; neither calcium salts, nor traces of aluminum are revealed. To obtain visible colour with 20 cc. of water containing 0.1 mg. aluminum hydroxide per liter, a few drops of N/5 or N/10 acetic acid must be used. Colour deepens with time; at least an hour is required to detect traces of hydroxide less than 0.095 mg. per liter. This wait can be avoided by adding a few drops of glycerine to sample.—*R. DeL. French.*

Contribution to the Study of the Bactericidal Power of Metallic Silver in the Presence of Colon and Typhoid Bacteria. A. Kling. Comptes Rend. Acad. Sci., **194**: 1402–1404, April 18, 1932. Large mass of very carefully cleaned silver immersed in double-distilled water in platinum apparatus, produces in water minute, but detectable, concentration of silver chloride, approximately 5×10^{-5}. This solution is definitely bactericidal to colon, or typhoid, bacillus, and retains this property even after boiling, or reduction to half-strength by dilution. Presence, or absence, of oxygen, hydrogen, or nitrogen, in surrounding atmosphere does not affect it. But if water contains calcium bicarbonate, precipitate of calcium carbonate formed on boiling removes the silver by adsorption, and activity is lost. Electrolysis, or even addition of common salt, is without effect. Hydrogen sulphide forms silver sulphide, and bactericidal property disappears. Silver in any condition may be used, except as "silver paper." To fit this for use it must be washed in nitric acid, water, and ammonia. pH value of the water to be treated does not matter; it may vary from 5.8 to 8.0. Solution of silver nitrate of concentration 1×10^{-5} acts like distilled water activated with metallic silver. Bactericidal action is due simply to slight solubility of silver in water.—*R. DeL. French.*

Importance of Chemistry in the Control of Public Water Supplies. J. R. Lorah. 6th Ann. Rep. Missouri Water and Sewerage Conference, 1930, **2**: 57–9. From Bull. of Hygiene, **7**: 10, 640–1, October 1932. For intelligent chemical control, knowledge of history of supply previous to its arrival at purification plant is indispensable. Sewage pollution can be handled by more or less standardized methods, but complications introduced by trade wastes frequently tax the chemist's ingenuity. In purification process itself, chemistry plays important part; as for example in alkalinity adjustment, floc formation, rates of reaction, and the like.—*Arthur P. Miller.*

Water-borne Outbreaks due to Pollution of Ground Water Supplies. A. E. Gorman. 6th Ann. Rep. Missouri Water & Sewerage Conference, 45–51. From Bull. of Hygiene, **7**: 10, 641–42, October 1932. In Kansas, only about

12 percent of ground water supplies exhibit perfect records for two successive years and less than 1 percent for 8 or 9 years. Of 57 disease outbreaks traced to pollution of underground supplies, 30 were found to be due to surface pollution of shallow wells. Sewers and sewage tanks are dangerous, if located close to shallow wells. Faulty well casings and seepage of contamination through creviced limestone were to blame in other cases. Ten of severest outbreaks of decade were due to pollution of underground water.—*Arthur P. Miller.*

An Epidemiological Study of the Removal of Night Soil and Drinking of Well Water in Keijo, Korea. M. Ogino and H. Mizushima. J. Pub. Health Assn. Japan, 8: 3–4, 1932. From Bull. of Hygiene, 7: 10, 642, October 1932. Authors studied relationships between night soil removal, consumption of well water, and death rate. Conclusions were that in areas where amount of night soil removed is small, or, in other words, where more night soil is thrown away, prevalence of infectious diseases and, consequently, death rate therefrom are higher. High death rate generally prevails in area where well water is used for drinking purposes and may be due to inferiority of water.—*Arthur P. Miller.*

Behavior of Activated Carbon with Metallic Water Purification Equipment. A. S. Behrman and H. Gustafson. Ind. Eng. Chem., 25: 59, 1933. Investigation following complaints of iron particles in water from commercial installation of activated carbon in steel container disclosed relatively high potential difference between carbon and container. When other metals replaced steel, observed voltage varied in general agreement with oxidation potential of metal employed. Degree of activation of carbons, as measured by ability to adsorb phenol, was in direct ratio to observed potential difference: this suggests a practical method for evaluating carbon efficiency. Under patent, non-conducting lining installed between carbon bed and metallic tank now serves to prevent trouble.—*Edw. S. Hopkins.*

The Classification of the Colon-Aërogenes Group of Bacteria in Relation to Their Habitat and Its Application to the Sanitary Examination of Water Supplies in the Tropics and in Temperate Climates. H. J. O'D Burke-Gaffney. The Journal of Hygiene, 32: 1, 85–131, January 1932. Comparative study of 2500 cultures of coliform bacteria was made, some 2000 in East Africa and remainder in England, material in each country including chosen well samples, other water samples, urine, soil, feces, and sewage. Methods and technique were uniform throughout; tests employed being indol, McConkey, methyl-red, citrate, Eijkman, and author's original direct plating method. Author's medium is glucose-phosphate-peptone of ordinary strength for methyl-red test, with addition of agar (2.7 percent) and brom-thymol blue (2.0 cc. 0.4 percent, aqueous, per litre). Medium is olive green; coli colonies appear after 24 hours at 37°C. as lemon-yellow discs on paler background, while aërogenes type show green. After four days, coli are orange and aërogenes, grass-green, on deep green background. Lactose+, indol+ index is usually in temperate climates an adequate criterion of water purity; but in tropics, false positive lactose-indol tests are common, owing to presence in soil and water of large numbers of

organisms derived from sources other than recently excreted feces. Direct plating method described gives presumptive evidence of presence of excretal *B. coli*. In tropics, lactose-indol test should always be confirmed by methyl-red, citrate, and saccharose tests; it is believed that methyl-red positive organism of soil has not same significance as methyl-red organism of feces, representing, at most, remote pollution. In temperate climates, wherever positive lactose-indol test does not appear to be substantiated by sanitary findings, further differentiation by methyl-red and citrate tests is satisfactory. Voges-Proskauer test applied to waters from temperate climate gave correlation of 97 percent with methyl-red test.—*W. G. Carey*.

Journal of the New England Water Works Association, March 1932. Vol. 46: No. 1. **History of the New Water Works Association.** Charles W. Sherman. 1–7. Review by past president on occasion of 50th Convention. Table of officers from 1882 to 1931 is appended. **The Boston Water Supply.** Frank A. McInnes. 8–23. March, 1932. After leaving Salem for Charleston in 1630, decision of Gov. Winthrop of Massachusetts Bay Colony to move on to Boston was influenced by abundance of excellent spring water. When springs and wells proved inadequate, Jamaica Pond was drawn upon. Main was of jointed pine logs until first 10-inch cast-iron pipe was laid in 1840. Cochituate system was completed in October, 1848. Per capita consumption soon reached astounding rate of 60 g.p.d., which led Water Board to recommend that wanton and illegal use of water be penalized. During water famine of 1871–2, additional supply from Sudbury River was authorized. Metropolitan Water Board was created in 1895, Boston Water Department retaining ownership in distribution system only. Construction is now in progress on Ware and Swift River supply, which will add 194 m.g.d. to Wachusett Reservoir. In 1930, average daily consumption of the 18 municipalities served was 92 m.g., of which Boston used 68 percent. Boston system comprises 4 services at different pressures, elevations served varying from grade 16 to 336. High-pressure fire system for protection of business district consists of 4 units in 2 stations, so controlled from switchboard that fire pressure of 150 pounds per square inch is available within one minute after alarm. With failure of fresh water, salt water can be utilized. Present supply should be sufficient for forty years; further potential source lies to west of Connecticut R. in valleys of Deerfield and Westfield Rivers. **The Relation of the Metropolitan Water Works to Its Member Communities.** David A. Heffernan. 24–32. Brief résumé of organization of Metropolitan Water District of Boston, including table showing population, per capita consumption, cost per 100 cubic feet, water works debt., etc., for each member community. Principal sources of revenue are: Water Rates (including meter rental), Service Installation, Hydrant Rentals, and Miscellaneous Jobbing. Variation in practice of individual members is marked: thus at Milton, Mass., commissioners insist that each branch of service provide sufficient income to cover its expenses; for service installation, customer pays invoice cost plus overhead. **Fifty Years in Water Works Practice.** Caleb M. Saville. 33–76. Progress in cast iron pipe manufacture is traced from early beginnings to so-called "sand-spun" or "mono-cast" centrifugal process. Tendency in conduits is toward

reinforced concrete and lock-bar steel pipe. Pumping engines date from 1872 when Holley Quadruplex engine was introduced as part of Holley system. Horizontal compound condensing type is contrasted with modern centrifugal and triplex pumps driven by electric motors, steam turbines, or Diesel engines. Evolution of dams and reservoirs, of water filtration, of methods of disinfection, of gate valves, and of meters is traced. While general price trend has been upward, savings in material and improved methods have done much to offset increased labor and freight rates. Lighter pipe with fewer joints and cheaper jointing material has proven its superiority, while machine excavation and back-fill have reduced labor charges. **The Brookline Water Works and F. F. Forbes.** M. N. Baker. 77–92. Fayette F. Forbes, connected with water works of Brookline, Mass., since 1873 and superintendant and engineer since 1875 was pioneer in removal of tastes and odors due to microörganisms, and was instrumental in adoption of covered reservoirs. Trouble with iron and manganese was conquered by aëration and filtration. Through his efforts Brookline, though constantly growing, was enabled for half a century to depend upon underground water. It is now a member of Metropolitan Water District of Boston. Original water works consisted of filter gallery near Charles River, gravity conduit of stoneware, or tile, pipe leading to steam pumping station, cast iron force main, and distribution system. Filter galleries were later expanded and wells driven to augment supply. In 1904, new covered reservoir was installed and in 1916, following trouble with iron and manganese, filter plant with coke tricklers and filters was constructed. Studies of water waste led to universal metering in 1891. **Water Consumption During Fires.** C. W. Mowry. 93–117. Too much stress cannot be laid upon importance of applying water as soon after outbreak of fire as possible. A pail of water may well prevent a conflagration. In test conducted by U. S. Bureau of Standards at Washington, a 2- and a 5-story building were ignited simultaneously on ground floor. In five minutes fire had spread to the roof and in 2 hours buildings had burned down. Fighting a dangerous fire at Fall River, Mass., with aid from surrounding towns, additional fire pumps drew 31 m.g.d., which exceeded capacity of water works units by 7 m.g.d. and emptied 2 stand pipes before fire was under control. Although fire-fighting total is only fraction of 1 percent of annual water consumption, yet rate during fire may exceed capacity of system. During fire at Spencer, Iowa, it was necessary to pump polluted water into system: other fires are cited. According to Standard Grading Schedule of National Board of Underwriters total quantity of water which should be available in city of 200,000 is 12,000 g.p.m. plus 2,000 to 8,000 g.p.m. additional for a second fire. High pressure systems are just as essential for municipalities as are private fire pumps for individual properties.—*T. F. Donahue.*

The Clarification of Washery Water from Coal Mines. W. Petersen and F. Gregor. Glückauf, 68: 28, 621–30, July 1932. Report on tests for clarification by means of electrolytes and protective colloids of three natural sludges from bituminous coal and gas coal washeries and of two prepared sludges, (1) from pure anthracite and (2) from wet pulverized argillaceous schist. Of special interest are the plant scale trials with potato flour, quite

small quantities of which (100 g., or less, per m.^{3}) so accelerate sedimentation that solids in reservoir effluent are reduced from 12.34 to 0.123 g. per liter, most of the starch remaining in the sludge. Potato flour specially pre-treated by freezing at 21°F., stirring into ice-cold water, and dissolving in hot soda-solution gave less favorable results. High starch-content is unfavorable for flotation. In small-scale tests, sludges exhibited distinct electric charge only after salts had been washed out. With addition of the electrolytes caustic soda, lime, sodium phosphate, and ferric chloride and of other protective colloids, glue, gelatine, gum, soap, etc., irregular reactions with sludges followed, so that no generally applicable rule can be established. In general way, results can be attributed to sensitization of electrolytic flocculation by protective colloids.—*Manz*.

Existence of the Bacteriophage in Water. K. SCHLOSSMANN. Zeitschrift für Hygiene und Infektionskrankheiten, **114**: 1, 65–76, June 1932. Samples from one river, three lakes, five ponds, and twelve wells were tested as to their contents of respective bacteriophages against bacteria of colon, typhoid, paratyphoid, and dysentery groups, cholera vibrios, Proteus vulgaris, Proteus X 2, Proteus X 19, and Pyocyaneus. At sampling all necessary precautions were taken to exclude interference from rain water. Results show that bacteriophage content depends largely upon local sanitary conditions. All samples rich in bacteriophages originated from places where primary fecal contamination was a priori probable. Under favorable hygienic conditions, surface waters were poor in, or free of, bacteriophages. In the twelve well samples, no bacteriophages could be detected. Following fecal pollution, bacteriophages first to be detected are those against dysentery bacillus. If, in addition, bacteriophages against colon, typhoid and paratyphoid germs are present, more serious fecal pollution is certain. In surface waters of Esthonia, bacteriophages against colon, dysentery, and paratyphoid bacteria, Shiga and Flexner bacilli, and cholera vibrios have been found.—*Manz*.

Koser's Uric Acid and Citrate Tests and Certain Other Methods for the Determination of Fecal Bacterium Coli in Water. G. LIND. Archiv für Hygiene und Bakt., **107**: 3–4, 234–242, January 1932. Eighty-eight strains of colon bacteria isolated from human feces were tested as to their behavior in EIJKMANN (87), indol (74), methyl red (81), VOGES-PROSKAUER (87), citrate (5) and uric acid (38) tests, the figures in brackets giving positive reactions in each case. Satisfactory correlation was found between citrate, indol, methyl-red and VOGES-PROSKAUER tests, but none between these and the uric acid test. Thus while most of strains tested failed to grow upon citrate medium, 38 out of 88 grew upon uric acid medium.—*Manz*.

Chironomus Control in Bathing Establishments, Swimming Pools, and Water Supplies by Means of Chlorine and Copper. WALTER BUCHMANN. Zeitschrift für Gesundheitstechnik und Städtehygiene, **24**: **B.**: 6, 235–42, June 1932. Copper alone, added as copper sulphate, was without any action upon Chironomus larvae, even in quantities of 2.92 grains per gallon, nor did it prevent emergence of larva from shell. Chlorine alone killed the larvae and more

quickly the higher the dosage, thus all larvae were killed with 1.51 grains per gallon after 1 hour 30 minutes, or with 0.76 grains per gallon after 3 hours 10 minutes and 80 percent were killed with 0.38 grains per gallon after 24 hours. When simultaneously with above quantities of chlorine about double as much copper was added, total killing was attained after 1, 2, and 20 hours, respectively. According to these results, 0.7 grains per gallon of chlorine is sufficient to destroy all larvae in 6 to 10 hours: if equal quantities of copper is also simultaneously added, then killing will be done considerably more quickly and effectively.—*Manz.*

NEW BOOKS

Proceedings Eighth Water Works Short Course Held at Oklahoma A. & M. College, 1932. Publication No. 15, Engineering Experiment Station, Stillwater, Okla., 1932. **Waste Water Survey.** W. R. Spencer. 30–4. Discusses importance of, and methods for, waste water surveys. **Fluorine in Water and Mottled Enamel.** Harrison Hale. 35–40. **Maintenance of Filter Gauges, Meters, and Rate Controllers.** L. C. Roberts. 42–3. Instructions in simple language for checking, setting, and calibrating filter gauges and rate controllers. **Zeolite and Its Application to Oklahoma Water Supplies.** J. T. Grimsley. 44–9. **Water Supply Problems During Flood and Major Disasters.** H. N. Old. 51–4. Also, under title **Water Supply Problems During Major Disasters.** Southwest Water Works Journal, 14: 3, 24–26, 1932. In floods, chief problem is, by carefully controlled chlorination, to secure adequate disinfection without creating unfavorable tastes, or odors, which would result in driving the population to unsafe supplies. In case of storms, the placarding of supplies is essential. Drouths have taught need for greater foresight in planning storage capacity, benefits of conservation by metering and by reduction of waste, and need for more information on taste and odor control. In earthquake regions, construction, whether of plants, or of distribution systems, in the vicinity of fault lines, or of lines of cleavage, should be avoided. There should always be available supplies of chlorine and hypochlorites, full information as to accessible sources of motive power, pumping equipment, pipes and containers, and contact with trucking and railroad facilities. (*Courtesy Chem. Abst.*). **Improper Construction as a Cause of Well Pollution.** A. G. Fielder. 56–60. Excellent discussion on locations to be avoided, on construction at surface and underground, on chlorination, and on proper operation. (*Courtesy Chem. Abst.*). **Powdered Activated Charcoal as a Water Purifier: What It Is, and Some Applications.** John P. Harris. 61–2. **Ammonia-Chlorine Treatment at Okmulgee, Oklahoma.** Ernest Skinner. 63–5. Chloramine effected reduction in cost per m.g. (of $1.20), in algae, in after-growths, and in tastes and odors, and increased residual chlorine. (*Courtesy Chem. Abst.*). **Effect of Salt Concentration on Chloramine Disinfection of Water.** Roy E. King and O. M. Smith. 66–7. Chloramine efficiency remains the same in presence of salt concentrations not exceeding 500 p.p.m.; but decreases in presence of concentrations of 2000 p.p.m., time factor being held constant. (*Courtesy Chem. Abst.*). **Construction and Operation of the Miami, Oklahoma, Municipal Swimming Pool.** H. G. Freehauf. 68–70. Description of 200- x 100-foot pool, constructed

at cost of $34,895. **The Ammonia-Chlorine Process and Its Development in the United States.** A. E. HOWE and L. H. BRANDT. 71–5. **Organization of Municipal Fishing and Its Relation to the Sanitary Water Works System.** A. D. ALDRICH. 76–9. Fish culture is among the duties of water works department. Tulsa, Oklahoma, employs a fish culturist, propagates its own fish, and stimulates this recreation. Methods are given.—*O. M. Smith.*

Handbook of Mathematical Tables and Formulas. RICHARD STEVENS BURLINGTON. Handbook Publishers, Inc. Sandusky, Ohio. 1933. Price $2.00.

Peptones. Booklet published by Difco Laboratories, Detroit, Michigan, May 1932. Peptones are intermediate products, formed after proteoses in the digestion of proteins and are regarded as peptids or mixtures of peptids. The story of peptones in relation to bacteriology is presented in a fairly comprehensive way. The various products of the Difco Laboratories are described. A bibliography of 86 references is included.—*A. W. Blohm.*